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PRICKLY PEAR AS STOCK FEED.

A Review of some Experiments in Queensland with *Opuntia inermis* (the Common Pest Pear).

By Frank Smith, B.Sc., F.I.C.

PRESIDENTIAL ADDRESS.

(Delivered before the Royal Society of Queensland, 30th March, 1921.)

FOREWORD.

In 1916-17 the author investigated the value as stock feed of the common pest pear (*O. inermis*) for the Queensland Government at Wallumbilla, Maranoa district. There was subsequently published by the Department of Agriculture a popular bulletin* in which the main conclusions of the investigation were set forth. Experimental data bearing on the value of the common pest pear have, however, not previously appeared.

The author is indebted to the Minister for Agriculture (Hon. W. N. Gillies) for permission to make the basis of this paper his technical manuscript dealing with the Wallumbilla experiments in possession of the department. The short description of the feeding trials is derived from, and the tabulated data upon which the conclusions here advanced are founded are reproduced by permission from the manuscript referred to.

INTRODUCTION.

The Prickly Pear Travelling Commission appointed by the Queensland Government to report on means of controlling the prickly-pear pest drew attention (7)† to the considerable use of opuntias as drought feeds and their systematic employment in productive rations for stock prevailing in various countries. In America and elsewhere the recognised value of opuntias had led to advocation of their cultivation as farm

* *The Feeding of Prickly Pear to Stock (1918).*

† The numerals in brackets refer to literature cited at the end of the paper.

crops. A leading recommendation of the Commission was that the utility as stock feeds of the prickly pears within the State should be investigated.

The principal naturalised opuntia of Queensland is *O. inermis*, a variety with few spines, though its abundant fine prickle necessitates preparation before feeding to stock. *O. inermis* was employed by the author in the trials with steers, dairy cows, and sheep here detailed. The trials with steers (1916) enabled a conclusion to be arrived at with regard to the wholesomeness and palatability of prickly pear, and were a useful preliminary to the work with dairy cows. The dairy herd experiments (1917) were designed to test the value of prickly pear as a roughage in rations for milk production. The sheep experimentation (1917) constitutes, it is believed, the first systematic trials of prickly pear with sheep recorded.

PART I.—PRICKLY PEAR IN THE RATIONS OF STEERS.

Plan of Experiment.

The animals employed in the experiments were eighteen mature steers, principally of Shorthorn and Hereford strains. The beasts were stall fed and kept in an enclosure bare of herbage. The prickly pear was harvested and passed through a power-driven Texan pear-slicer before feeding, but not otherwise prepared.

The main trials are described as maintenance trials, but, the rations providing generally nutriment in excess of that necessary to merely preserve body weight, they are such in the economic rather than the strict physiological sense. Two series were conducted, viz. :—One in the winter season when a small amount of hay was provided as roughage in addition to prickly pear ; the second in spring when, after recognition of the restriction by other feeds of the prickly pear consumed, the feeds supplementing prickly pear were limited to concentrates or legume hay for the supply of necessary protein.

The insufficiency of prickly pear alone for the maintenance of beasts was demonstrated in the first trials.

The recognition of the importance of palatability of a feed in its evaluation led to some study of the appetite displayed by experimental animals for prickly pear. The number of

individuals employed therein was small, but was considered sufficient to enable the factors by which appetite might be influenced to be well discerned.

The effect of administration of water to pear-fed animals was investigated during the second trials, when the progress of watered and unwatered animals was compared.

The continuance of prickly pear feeding for from seven to eight months provided ground for pronouncement on the effect of the feed on the health of animals, judged both by their obvious condition at the end of the feeding and by post mortem appearance.

Maintenance Trials. Feeds Consumed Daily and Alteration of Body Weights.

First Trials (50–70 *days*).—Four groups of animals were utilised, viz. :—(1) Three animals received prickly pear alone ; (2) five animals received prickly pear with a little hay roughage ; (3) six prickly pear, a little hay, and meal ; (4) four prickly pear, hay, and legume hay. The prickly pear was of 86–87 per cent. water content, and as much was supplied as was eaten. The meal was linseed meal or cocoanut cake. The hay was wheaten and panicum hay, fed chaffed ; the legume, chaffed lucerne hay. The data for the trials are given in Table 1.

Second Trials (50–55 *days*).—The disposition of the experimental animals was as follows :—(1) Seven received prickly pear and chaffed lucerne hay ; (2) eleven received prickly pear and meal (either linseed meal, cocoanut cake, or maize germ-meal). As much prickly pear was given as was eaten, and no hay roughage was supplied. The prickly pear varied in water content from 82–86 per cent. The amount of meal or legume fed in both the first and second trials was made to provide protein at least adequate to the maintenance of the animals. The rations fed in the second trials and the gains made are summarised in Table 2.

The weights recorded are based on ten weighings on successive days about the initial and final days of the periods. The weighings were made immediately after the morning meal of prickly pear, and as they were obviously influenced by the amount of pear taken they were corrected accordingly, being brought to a basis of a sixty-pound prickly pear consumption. This method of correction would appear to be necessary where

there is variation in the amounts of roughage consumed daily, and is thought to be productive of as great accuracy as is commonly possible in this class of experiment.

TABLE 1.—FIRST MAINTENANCE TRIALS. FEEDS DAILY, AND INITIAL AND FINAL BODY WEIGHTS.

Group.	Number of Animal.	Days.	FEEDS.				BODY WEIGHTS.		
			Prickly Pear.	Hay.	Lucerne	Meal.	Initial.	Final.	Gain.
			Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Prickly pear ..	7	50	54·8	..	..	..	1,057	988	−69
	12	..	53·0	..	..	..	1,021	963	−58
	16	..	47·5	..	..	..	1,005	935	−70
Prickly pear and hay	5	65	49·3	7·38	..	..	967	970	3
	9	..	42·0	8·31	..	..	946	948	2
	13	..	44·4	8·00	..	..	1,042	1,035	−7
	13	..	48·3	7·72	..	..	961	964	3
	15	..	41·5	8·15	..	..	1,086	1,079	−7
Pricky pear and meal (with hay)	2	70	68·3	1·81	..	1·96*	951	967	16
	4	..	55·0	2·13	..	2·51†	932	965	33
	8	..	72·5	1·56	..	1·86*	962	974	12
	10	..	58·5	2·03	..	2·52†	957	979	22
	14	..	42·1	3·53	..	1·83*	917	923	6
	17	..	57·6	1·74	..	2·18†	875	908	33
Prickly pear and legume (with hay)	1	70	80·2	·93	3·71	..	1,109	1,126	17
	3	..	69·8	1·31	3·50	..	957	980	23
	6	..	79·0	1·23	3·71	..	1,105	1,125	20
	18	..	68·9	1·31	3·58	..	962	976	14

* Linseed meal. † Cocoanut cake.

TABLE 2.—SECOND MAINTENANCE TRIALS. FEEDS DAILY, AND INITIAL AND FINAL BODY WEIGHTS.

Group.	Number of Animal.	Days.	FEEDS.			BODY WEIGHTS.		
			Prickly Pear.	Lucerne	Meal	Initial.	Final.	Gain.
			Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Prickly pear and meal ..	2	50	67·9	..	2·00†	982	1,013	31
	4	..	54·3	..	2·50‡	966	997	31
	8*	55	78·7	..	2·00†	975	1,003	28
	10*	50	55·1	..	2·25§	985	1,001	16
	12	55	62·6	..	2·50§	1,012	1,030	18
	13	..	63·8	..	2·00†	959	989	30
	14*	..	52·6	..	1·75†	928	930	2
	15*	..	54·2	..	2·50§	1,064	1,080	16
	16	..	60·3	..	2·50§	981	1,000	19
	17	..	58·1	..	2·25§	918	939	21
	18	..	69·5	..	2·00§	971	1,007	36
Prickly pear and lucerne ..	1	50	73·7	3·50	..	1,127	1,153	26
	3	..	71·0	3·00	..	985	1,003	18
	5	..	76·0	3·00	..	984	1,029	45
	6*	..	74·4	3·50	..	1,122	1,157	35
	7	55	70·0	3·50	..	1,000	1,038	38
	9	50	71·4	3·00	..	952	980	26
	11*	..	65·2	3·25	..	1,047	1,078	31

* Watered daily for 30 days. † Linseed meal. ‡ Cocoanut cake. § Maize germ meal.

Maintenance Trials. Nutritive Value of Feeds and Average Daily Gains.

The net nutritive value of the feeds is computed in the starch equivalent system of Kellner (5). It was not possible to determine the digestibility of the prickly pear and other feeds by separate experiment. Therefore the digestibility coefficients adopted for prickly pear were those of American varieties (3, 9), the digestibility of prickly pear protein being taken as 71·6 per cent.*

Table 3.—Starch Equivalents and Digestible Protein of Ration Daily, and Average Daily Gains.

Group.	Number of Animal.	Prickly Pear. Starch Equivalents.	Prickly Pear. Protein.	Other Feeds. Starch Equivalents.	Other Feeds. Protein.	Total. Starch Equivalents.	Total. Protein.	Gains.
		Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
First Trials.								
Prickly pear	7	4·30	·15	..	..	4·30	·15	−1·38
	12	4·24	·14	..	..	4·24	14	−1·16
	16	3 72	·13	..	..	3 72	·13	−1·40
Prickly pear and hay	5	3 85	·13	3 05	·35	6 90	·48	·05
	9	3·26	·12	3·47	·38	6·73	·50	·03
	11	3·46	·13	3·35	·40	6·81	·53	− ·12
	13	3·81	·14	3·20	·37	7·01	·51	·05
	15	3·28	·12	3·39	·41	6·67	·53	− ·12
Prickly pear and meal (with hay)	2	5·40	·18	2·41	·50	7·81	·68	·23
	4	4·36	·15	2·90	·48	7·26	·63	·47
	8	5·72	·21	2·24	·47	7·96	·68	·17
	10	4·62	·17	2·77	·45	7·39	·62	·30
	14	3·33	·12	3·07	·53	6·40	·65	·09
	17	4·47	·16	2·42	·40	6·89	·56	·47
Prickly pear and lucerne (with hay)	1	6·36	·23	1·93	·61	8·29	·84	·25
	3	5·23	·20	2·02	·59	7·25	·79	·33
	6	6·29	·22	1·91	·61	8·20	·83	·29
	18	5·45	·19	2·05	·60	7·50	·79	·20
Second Trials.								
Prickly pear and meal	2	6·43	·21	1·63	·48	8·06	·69	·62
	4	5·50	·18	1·86	·38	7·36	·56	·62
	8	7·28	·25	1·63	·48	8·91	·73	·51*
	10	5·41	·18	2·34	·37	7·75	·53	·32*
	12	5·64	·18	2·50	·39	8·14	·68	·33
	13	5·99	·20	1·63	·48	7·62	·68	·54
	14	4·91	·16	1·42	·42	6·33	·58	·04*
	15	5·16	·17	2·49	·40	7·65	·57	·29*
	16	5·99	·20	2·49	·39	8·48	·59	·35
	17	5·45	·18	2·24	·35	7·69	·53	·37
	18	6·49	·21	1·62	·48	8·11	·69	·65
Prickly pear and lucerne ..	1	6·95	·23	1·50	·58	8·45	·81	·52
	3	6·65	·22	1·29	·49	7·94	·71	·36
	5	7·19	·24	1·29	·49	8·48	·73	·90
	6	7·03	·23	1·50	·58	8·53	·81	·70*
	7	6·55	·22	1·50	·58	8·05	·80	·69
	9	6·73	·22	1·29	·50	8·02	·72	·52
	11	6·16	·20	1·39	·54	7·55	·74	·62

* Watered daily for 30 days.

* Digestibility by pepsin in vitro 70-73 per cent.

The digestibility of the protein of the hays was determined by pepsin in vitro; the digestibility of the carbohydrates was arrived at according to Henneberg's rule* in preference to accepting the digestibility coefficients found for the varieties elsewhere. For the meals the digestibilities and starch equivalents were as given by Kellner. The starch equivalents of the prickly pear and hays were obtained from the starch values by deduction of ·29 per cent. for each one per cent. of fibre (5).

THE STRICT MAINTENANCE REQUIREMENT OF PRICKLY PEAR FED STEERS.

The rations in the maintenance trials were generally sufficient for the production of small gains. The nutrients of the rations utilised for preservation of body weight can be deduced from the total nutrients by deduction of 3·0 lb. starch equivalent and ·3 lb. protein for each one pound gained, these amounts being shown in feeding trials with oxen to be adequate for that amount of fattening increase (6). By this method the requirement of individual steers for strict maintenance in the first trials is found to range from 5·85 to 7·34 lb. starch equivalent, and from ·44 to ·74 lb. digestible protein daily. In the second trial the range was 5·50 to 7·43 lb. starch equivalent, and ·43 to ·69 lb. digestible protein. Per 1,000 lb. live weight the average daily maintenance requirement of steers shown in the first trials is 6·80 lb. starch equivalent and ·62 lb. digestible protein; in the second trials 6·39 starch equivalent and ·56 lb. digestible protein. The figures agree closely with the maintenance requirement for oxen of other fodders shown by various experiments—viz., 6·0 lb. starch equivalent and ·6 lb. digestible protein (5). The inference is that *prickly pear nutrients are well used in the maintenance of steers and for production of body weight increase.*

THE APPETITE OF STEERS FOR PRICKLY PEAR.

A study of the factors influencing the amounts of prickly pear eaten by steers was made partly during the maintenance trials and partly subsequent to them. The conclusions bearing upon the appetite of steers for prickly pear are dealt with in the following paragraphs:—

* *See* Crowther and Ruston. *J. Agric. Sci., vol. iv, 1914, p. 310.*

Prickly Pear as Sole Feed.—The amounts of succulent prickly pear eaten by three steers when the sole feed in a fifty-day trial ranged from 40 to 60 lb. per day. With three other steers in a ten-day trial *the average daily consumption did not exceed 60 lb. per day.* The starch equivalent of the average prickly pear ration slightly exceeded 4·0 lb.

Influence of Supplementary Feeds.—The effect of feeding protein supplying feeds in small amount is to increase the amount of prickly pear eaten by steers. Thus steer 16 when fed meal in the second maintenance trials ate 5·99 lb. starch equivalent prickly pear per day, as against 3·72 when pear was the sole feed. Steer 7 averaging 4·30 lb. starch equivalent when confined to prickly pear took 6·55 lb. when lucerne hay was also given. The feeding of meal increased the consumption of steer 12 from 4·24 to 5·64 lb. starch equivalent prickly pear. Supplementary feeds poor in protein do not similarly increase appetite for prickly pear. Steer 7 when fed millet hay equal in nutriment to the lucerne took only 3·90 lb. starch equivalent prickly pear; the appetite of steer 5 for prickly pear when lucerne was replaced by millet hay fell from 7·19 to 4·16 lb. starch equivalent.

Effect of Degree of Supplementation.—It was recognised early in the trials that *increase in the amount of other feeds given decreased the amount of prickly pear eaten.* Tables 4 and 5 show

TABLE 4.—RATIONS BY GROUPS. PRICKLY PEAR VARIOUSLY SUPPLEMENTED.

Numbers of Animals.	Supplement.	Starch Equivalent per 1,000 lb.		
		Supplement.	Prickly Pear.	Total.
		Lb.	Lb.	Lb.
5, 9, 11, 13, 15 ..	Hay	1·80	5·00	6·80
		3·19	3·83	7·02
		4·74	2·85	7·59
2, 4, 8, 10, 14, 17 ..	Meal and hay ..	2·06	5·48	7·54
		3·06	4·94	8·00
13, 6, 18	Lucerne and hay ..	1·40	6·43	7·83
		2·33	5·30	7·63
2, 4, 8, 10	Meal	1·96	6·47	8·43
		5·66	4·12	9·78
3, 5, 9, 11	Lucerne	1·32	6·74	8·06
		3·40	5·03	8·43

the reduction of prickly pear nutrients used by experimental animals when the supplementary feeds were increased. All the rations are on the basis of consumption per 1,000 lb. live weight :—

TABLE 5.—INDIVIDUAL RATIONS. PRICKLY PEAR VARIOUSLY SUPPLEMENTED.

Number of Animal.	Supplement.	Starch Equivalent per 1,000 lb.		
		Supplement.	Prickly Pear.	Total.
		Lb.	Lb.	Lb.
2	Meal	1·70	6·76	8·46
		5·64	4·86	10·50
4	..	2·0	5·90	7·90
		5·76	2·28	8·04
8	..	1·69	7·58	9·27
		5·58	3·66	9·24
10	..	2·45	5·65	8·10
		5·63	4·71	10·34
3	Lucerne	1·31	6·75	8·06
		3·43	4·91	8·34
5	..	1·31	7·30	8·61
		3·39	5·36	8·75
9	..	1·35	7·06	8·41
		3·54	4·67	8·21
11	..	1·30	5·91	7·21
		3·16	5·17	8·33

The replacement of prickly pear is not, however, strictly proportional to the increased amounts of other feeds, and generally the total nutritive value is increased by more liberal feeding. The reduction in amount of prickly pear eaten is less with meals than with hays, due no doubt to the bulkier character of the latter. *The daily consumption per head of prickly pear by the steers when fed with minimum but sufficient quantity of other feeds ranged generally from* 60 *to* 90 *lb.*

Effect of Succulence of Prickly Pear.—The seasonal drying out of the prickly pear during the second maintenance trials was perceived to be accompanied by some alteration in the amounts consumed daily by experimental animals. In order to show the influence of the drying out of prickly pear on the amounts eaten by the steers, Table 6 has been prepared. The data are for thirteen animals over successive ten-day periods.

TABLE 6.—VARIATION IN CONSUMPTION WITH ALTERATION IN WATER CONTENT.

Per Cent. Water.	Average per head per day.		
	Prickly Pear.	Dry Matter.	Starch Equivalent.
	Lb.	Lb.	Lb.
85·14	66·9	9·96	5·94
84·35	64·6	10·06	6·04
	61·8	10·20	6·18
82·42	59·6	10·47	6·20
85·04	64·2	9·60	5·84
85·75	68·0	9·70	5·88

With diminution in water content of prickly pear the amounts consumed are progressively diminished, but the amounts of dry matter ingested and nutrients utilised are slightly increased. The indication is that somewhat fuller employment of prickly pear will be made when the water content is below that of the highest succulence. Probably an upper limit would be reached, after which loss of succulence would render the plant less palatable to cattle.

Effect of Watering Cattle on Consumption of Prickly Pear.—Six of the steers were each given water on thirty consecutive days in the second maintenance trials. *The giving of water had little effect on the appetite of the animals for prickly pear.* Thus the average consumption during the days on which water was given was 6·02 starch equivalent, on the other days 6·42 starch equivalent. The remaining steers during the periods for which the comparison was made ate 6·33 and 6·35 starch equivalent of prickly pear.

Attempted Improvement of Palatability of Prickly Pear.—No method of feeding prickly pear—as feeding after boiling the joints, after singeing or roasting, or feeding salted or admixed with palatable meals—was found to increase the amounts eaten by the steers.

THE WATER REQUIREMENT OF PRICKLY PEAR FED STEERS AND THE EFFECT OF WATERING.

The water supplied by the succulent prickly pear was evidently sufficient for the steers in the winter season. During the first maintenance trials and thereafter for a total of 150 days, the animals had no other water supply than that furnished by the pear. In warmer weather during the second trials it

was deemed advisable to water the steers at least about each fifth day. Certain of the animals given water each day were found to drink from *nil* on cool days to 6 gallons per head during hot spells. The animals offered water at intervals drank freely.

As already shown, the administration of water has but little effect on the consumption of prickly pear by beasts. Nor is it apparent that watering is directly harmful. Although scouring was more marked in the case of the six steers given water daily for thirty days in the second maintenance trials, it was apparently in no way harmful, and these made body weight gains equal to those of the other animals. (*See* Tables 2 and 3.)

Prickly Pear—Forest and Scrub Growth.

The view has been held by some cattle-men that the prickly pear sheltered by scrubs is more valuable and nutritious than that occurring in open forest land. During the first maintenance trials the scrub form was for a period substituted for the ordinary forest growth. There was no indication that the experimental animals made any discrimination when both forms were placed before them in the feed-boxes. The two forms have practically the same composition, are apparently of equal feeding value, and were equally utilised in the feeding trials (Table 7):—

Table 7.—Forest and Scrub Prickly Pear.

——	Composition.							Utilisation.
	Water.	Dry Matter.	Ash.	C. Protein.	C. Fibre.	N.-free Extract.	Ether Extract.	S.E. Per Day.
								lb.
Scrub ..	86·46	13·54	2·48	·40	1·77	8·81	·08	4·43
Forest ..	86·41	13·59	2·36	·37	1·80	8·97	·09	4·47

Cow Pear.

It is a matter of frequent observation that cattle agisted on prickly pear are accustomed to browse certain plants, commonly referred to as "cow pear," to the exclusion of those adjacent. It has been assumed that the preference is on account of distinguishing flavour or instinctive recognition of greater nutritive value. The preferred plant is recognised by

more observant stockmen by a more swarthy hue of the joints and by the bearing of few, aborted, or seedless fruits. The joints are thicker, inclining to club-like, are less acid, and have a slightly fruity odour when cut. Dr. White-Haney at the Dulacca Station (8) devoted some attention to plants apparently identical with those noticed, principally in the direction of establishing absence of fecundity in the flower. Dr. White-Haney did not, however, note the comparative absence of prickle which the author has observed to be a constant characteristic.

The relative palatability of ordinary and cow pear were tested by placing both forms, prepared by slicing, before the experimental animals. For a few days there was shown a distinct preference for the cow pear, due no doubt to appreciation of its lesser acidity after the ordinary form ; thereafter the ordinary form appeared to be eaten with as much relish.

In Table 8 are compared the compositions of cow pear and ordinary prickly pear at the same season, and also the utilisation of each when fed over two periods to a group of animals in the second maintenance trials :—

TABLE 8.—ORDINARY PRICKLY PEAR AND COW PEAR.

—	COMPOSITION.							UTILISATION.
	Water.	Dry Matter.	Ash.	C. Protein.	C. Fibre.	N.-free Extract.	Ether Extract.	S.E. per day.
								Lb.
Ordinary Prickly pear	87·25	12·75	2·18	·35	1·25	8·66	·11	4·40
Cow pear	83·16	16·84	1·93	·33	1·76	12·72	·10	4·80

The higher utilisation shown for the cow pear may be attributed to its superior dryness.* (*See* p. 9.) The preference shown for cow pear by cattle at pasture is, no doubt, due to the absence of prickliness, such prickle as is present being soft and downy in character. The ordinary form was equally acceptable when its abundant prickle was detached and abraded by passage through the cutter, or softened by the juice exuding from the sliced and pulped joints.

* Dr. White-Haney's "Abnormal form" also has a lower water content than ordinary prickly pear.

THE WHOLESOMENESS OF PRICKLY PEAR.

The good condition of the steers at the conclusion of seven to eight months' feeding was evidence that prickly pear is a wholesome cattle feed. Certain of the animals were slaughtered and made subject of post-mortem examination. The report (10) of the veterinary surgeon, Mr. A. McGown, M.R.C.V.S., states that the carcasses were well nourished and entirely healthy; flesh of good colour, nicely grained, and of good quality; fat evenly distributed, good clear white in colour and of good quality. Certain changes were evident in the alimentary canal—viz., some signs of occasional slight ulceration of tongue and fauces, roughened palate, and enlarged papillæ both of cheek and rumen, thickened and toughened mucous membrane of certain organs.

The slight lesions described would have been caused by portions of spines included in the feed. They are accidental rather than necessary effects of the feeding of chopped *O. inermis*. Animals browsing the pest pear are apt, however, to sustain some injury from spines, as evidenced by spines occasionally found embedded in the tongue and the occurrence of abscess of the jaw and fauces. Cattle constrained by hunger to browse the prickly form of *O. inermis* may suffer from sore mouth to an extent preventing further feeding. The alterations noted in the post-mortem are ascribed to the prickle ingested and the nature of the feed.

Ranchers in Texas are reported to lose cattle from the effects of accumulation of prickly pear fibre in the stomachs (2). The condition is said never to occur from feeding chopped prickly pear, and is obviated by inclusion of a reasonable amount of other feed in the dietary. In local experience it would appear that fibre balls are but rarely encountered in slaughtered beasts. Cases of bloat are reported from America. Bloat could, no doubt, be caused by surfeit. The amount of *O. inermis* that steers are willing to eat appears, however, to be substantially lower than obtains with certain American species. Owing probably to the watery character of the feed and the low fibre content, rumination is restricted in animals receiving a high proportion of prickly pear in the dietary. The assertion that has been made that feeding on prickly pear unfits cattle for grass pasturage is, however, negatived by the fact that steers employed in the trials subsequently made good gains at grass and were eventually marketed in prime condition.

The Utility and Limitations of Prickly Pear as a Roughage for Steers.

The trials here described demonstrate the ability of rations comprising a high proportion of prickly pear properly supplemented by other feeds to produce substantial gains in steers. Prickly pear is a satisfactory sole roughage fed with meals.

The insufficiency as a maintenance feed of prickly pear alone was shown in the first maintenance trials when three steers receiving it and no other feed rapidly lost weight, scoured badly, and exhibited stariness of coat and other signs of unthriftiness. Steer No. 16, initially in rather low store condition, showed signs of weakness at the end of fifty days, when all three were given meal or lucerne in addition to prickly pear. Thereupon improvement in appearance and condition was soon noticed.

Animals receiving a medium allowance of ordinary hays, though maintaining body weight during sixty and sixty-five day periods, showed in dulness of coat sign of unthriftiness attributable to improper rather than insufficient feed.

Besides its use as a maintenance feed and drought emergency fodder, the employment of prickly pear in rations for fattening steers is reported from Texas, cotton-seed meal being generally combined with it for the purpose. Griffiths (1) records good results with this ration at Encinal, Texas. Twenty-seven head fed chopped prickly pear, and consuming 96 lb. per head and about 4·4 lb. cotton-seed meal daily, averaged in gain $1\frac{3}{4}$ lb. per day. For this result the starch equivalent of the daily ration would have approached 12 lb., of which the prickly pear contributed 9 lb.

With *O. inermis* the highest ration, including medium allowance of meal, consumed by steers does not, as shown in the experimental part of this paper, much exceed 10 lb. starch equivalent, adequate only to production of 1 lb. fattening increase daily. It is also shown that increase of meal with the object of improving the ration would reduce the amount of prickly pear eaten, and the total nutritive value of the ration would not be increased proportionately to the added meal. A rate of fattening increase equal to that of the Texan experiments quoted could not, therefore, be procured except by including high amounts of meal in the feed, which would then comprise a comparatively low proportion of prickly pear.

The inferior utility for purposes of fattening that is shown for *O. inermis* might reasonably be attributed to a lower palatability to cattle than is possessed by the species employed in the Texan trials. The medium order of palatability demonstrated for it would indicate that the utility of the pest pear for beef cattle is as a maintenance feed rather than as a roughage in rations designed for economic productive purposes.

Agistment Problems.

There has been much variance of opinion among cattlemen as to the value of standing prickly pear in agistment, and considerable uncertainty has existed as to the factors contributing to the carrying capacity of prickly pear lands. It has been commonly held that prickly pear has been instrumental in drought in saving cattle not removed to more favoured regions for pasture, and that at all seasons dense prickly pear areas are capable of carrying and turning out a certain number of beasts in fat condition. It has also been claimed that cattle can exist for long periods or indefinitely with no other water supply than is provided by succulent prickly pear, and that access to water may be attended by harmful or even fatal results.

It is thought possible to obtain a solution of certain vexed questions in prickly pear agistment by application of the results of the feeding trials. It has been shown that the various forms of prickly pear differ but slightly in nutritive value and utility to the beast, save that the comparatively prickle-free form (cow pear) alone allows of free browsing. Prickly pear alone, chiefly due to poverty in protein, has been shown to be insufficient for the maintenance of cattle, which depends on provision of protein-supplying feeds as supplements to the prickly pear.

In many areas the deficiency of protein of prickly pear is made good by naturally occurring edible shrub. In the typical prickly pear scrubs of the Maranoa there were observed as many as thirty varieties of shrub or small tree recognised by consensus of reliable opinion as edible to cattle, though of varying palatability and protein content. The main factors in the carrying capacity of prickly pear areas are abundance of edible prickly pear ("cow pear") and sufficiency of protein-supplying edible shrub—conditions that no doubt characterise the best prickly pear scrubs. A combination of prickly pear

and lucerne hay in medium amount was shown in the trials to be capable of producing in steers increase exceeding $\frac{1}{2}$ lb. per day. A similar ration of prickly pear and edible shrub, which should be not infrequently obtainable in the scrubs, would, there appears every reason to assume, be productive of similar increase. The limitation of the prickly pear ration by the restricted appetite shown for it by steers would, however, generally limit the rate of fattening increase to a moderate figure, which, though attained in the earlier stages of fattening, would be insufficient to ultimately, in the most favourable circumstances, produce beasts of more than moderately fat or good store condition.

Accordingly as the edible pear is limited in amount or the edible shrub is insufficient, cattle will fail to do well. The prime beast occasionally reported would appear to be exceptional and to depend on utilisation of other and better grazing than prickly pear and shrub, or on a higher appetite for prickly pear than is shown by the average animal.

The appetite of steers for prickly pear is such as to enable their water requirements to be satisfied by the plant at least in cool weather. In hot seasons the highest degree of succulence may suffice, whereas in prolonged drought, owing to the drying out of the prickly pear, the holding of cattle on unwatered country is no doubt highly hazardous, and may entail heavy loss. The administration of water to prickly pear fed animals has been shown to be, *per se*, unharmful. Yet it would appear that close frequentation of water by cattle during very hot seasons might prove a disadvantage, owing to depletion of the edible prickly pear in the vicinity and eating out of edible shrub. The reported losses of prickly pear agisted cattle having access to water would seem to be accidental, due in drought to immoderate drinking of water induced by prolonged thirst, and would include animals that have perished after bogging at the margins of waterholes.

The appetite displayed by milking cows for prickly pear (*see* Part II.) would indicate that, if the supply of protein-rich shrub is abundant, cows will be maintained in milk sufficient for the nourishment of calves at foot. The very limited appetite of calves for prickly pear* would show that prickly pear and shrub browse, partly because of the inaccessibility of the

* The author's experiments with calves not here reported.

shrub, will not adequately provide for sustenance and growth of young stock, which, indeed, appears to be the experience of most cattle-men.

PART II.—PRICKLY PEAR FOR DAIRY HERDS.

Griffiths (2) records the regular use of prickly pear for dairy herds in Texas, and later (1) shows its suitability for roughage in a trial with two milk cows. In Sardinia employment in suitable rations is regarded as advantageous. More recently Woodward, Turner, and Griffiths (9), in a comprehensive trial at Brownsville, Texas, have demonstrated the possibility of using prickly pear in considerable proportion in rations for milk production. Locally, apart from a limited use of the boiled joints generally fed with bran or the enforced browsing of edible prickly pear in drought, the plant has not found any general use for dairy herds.

The utility of prickly pear as a feed for dairy cows depends fundamentally on the actual value of the prickly pear nutrients in the rations, but will be conditioned by such considerations as the cost of feeds, both relative and actual, with which it might be fed or replace in the ration. In this paper the value of the nutrients of prickly pear in milk production alone is discussed without reference to the economic side.

Plan of Experiment.

In the author's main experiments fifteen dairy cows were utilised—pure and grade Ayrshires, grade Shorthorns, and Jersey grade. Of these, seven were acquired in the district and were doubtless accustomed to prickly pear in the pasture. The plan was to compare prickly pear as a roughage feed, both as regards its efficiency in the ration and effect on the quality of the product, with a usual roughage, which in this case was mature Soudan grass (*Sorghum* var.) hay coarsely chaffed. The concentrates completing each ration were wheat-bran and linseed meal in equal quantities.

As it was evident from the work with steers that prickly pear was not a highly palatable feed, it appeared probable that enough would not be eaten by the cows, when liberally supplemented by meal, to constitute a ration adequate to high milk yields. Accordingly the trials were preceded by a

preliminary period, when all received a ration of meal and as much prickly pear as was eaten for long enough to allow the yields to recede to a level commensurate with the highest prickly pear ration that could be fed to each.

Three comparisons were made—viz., prickly pear alone *vs.* Soudan grass hay; prickly pear *vs.* prickly pear and hay; and prickly pear and hay *vs.* hay. In addition, two cows were fed prickly pear continuously. The comparisons were made during forty-day periods, the first ration being fed in two separate half periods of twenty days, the second in an interposed forty days. The cows were grouped and fed as shown in Table 9 :—

TABLE 9.—GROUPS, RATIONS, AND PERIODS.*

No. of Cows.	RATION.		
	First Ration (20 days).	Second Ration (40 days).	First Ration (20 days).
5 ..	Prickly pear and meal ..	Hay and meal ..	Prickly pear and meal.
5 ..	Prickly pear and meal ..	Prickly pear, hay, and meal	Prickly pear and meal.
3 ..	Prickly pear, hay, and meal	Hay and meal ..	Prickly pear, hay, and meal
2 ..	Prickly pear and meal continuously†		

* Ten days' transition periods for changing feeds were allowed.
† Five months.

The prickly pear was of about 85 per cent. water content, and was prepared by passing through a Texan prickly pear slicer. Generally as much was fed as was eaten. In the second period as much hay was given as produced about the same body weight gains as were previously obtained with prickly pear. Allowance of meal was made to provide protein in accordance with the Haecker standard for milch cows (4). The meal allowance was adjusted to the butter-fat yield every tenth day. The prickly pear and other feeds were regularly analysed. The digestibility coefficients of the feeds were obtained in the manner employed in the work with steers. The milk was weighed at each milking and analysed each alternate day during the periods. The fat content and specific gravity were determined and the solids-not-fat calculated by Richmond's formula. The initial and final body weights were each based on ten consecutive daily weighings, corrected as in the work with steers.

Milk Production, Feeds, and Body Weights.

Tables 10 and 11 give the data by groups relative to yields, feeds, and alterations in body weights.

Table 12 deals with the starch equivalents and content of digestible protein of the rations.

TABLE 10.—GROUP YIELDS OF MILK, BUTTER-FAT, AND SOLIDS-NOT-FAT. FORTY-DAY PERIODS.

Nos. of Cows.	Ration.	Milk.	Butter-Fat.		Solids-not-Fat.	
		Lb.	Lb.	Per cent.	Lb.	Per cent.
Group 1—						
10, 11, 12, 13, 14	Prickly pear and meal	3,447	145·27	4·21	295·99	8·58
	Hay and meal ..	3,333½	162·54	4·87	285·99	8·54
Group 2—						
9, 16, 17, 18, 19	Prickly pear and meal	3,770¾	152·43	4·03	326·31	8·65
	Prickly pear, hay, and meal	3,920	168·82	4·31	340·58	8·68
Group 3—						
1, 4, 6	Prickly pear, hay, and meal	2,010¾	80·73	4·01	165·91	8·20
	Hay and meal ..	1,987	80·44	4·25	163·65	8·24

TABLE 11.—GROUP RATIONS AND GAINS IN BODY WEIGHTS. FORTY-DAY PERIODS.

Nos. of Cows.	Rations.	FEEDS CONSUMED.			Gains.
		Prickly Pear.	Hay.	Meal.	
Group 1—		Lb.	Lb.	Lb.	Lb.
10, 11, 12, 13, 14 ..	Prickly pear and meal ..	12,498	..	1,676	40
	Hay and meal ..	..	2,208	1,845	46
Group 2—					
9, 16, 17, 18, 19 ..	Prickly pear and meal ..	11,868	..	1,738	24
	Prickly pear, hay, and meal	8,321	792	1,980½	38
Group 3—					
1, 4, 6	Prickly pear, hay, and meal	3,283	561	982½	32
	Hay and meal	..	1,377	1,017	37

Comparing the yields, it is seen that prickly pear as the sole roughage produced more milk but less butter-fat than did the hay roughage.

The part roughage of prickly pear (prickly pear and hay) likewise produced more milk and less fat than the whole roughage of hay.

The part roughage of prickly pear produced more milk and more butter-fat than the whole prickly pear roughage.

Prickly pear reduced the fat percentage in the milk, but did not appreciably alter the content of solids-not-fat.

TABLE 12.—STARCH EQUIVALENT AND DIGESTIBLE PROTEIN OF GROUP RATIONS. FORTY-DAY PERIODS.

Numbers of Cows.	Rations.	—	Prickly Pear.	Hay.	Meal.	Total.
			Lb.	Lb.	Lb.	Lb.
Group 1—						
10, 11, 12, 13, 14	Prickly pear and meal ..	S. equivalent	1,062·85	..	1,071·68	2,134·53
		Dig. protein	34·06	..	304·75	338·81
	Hay and meal	S. equivalent ..	..	660·55	1,177·40	1,837·95
		Dig. protein ..	..	43·46	330·64	374·10
Group 2—						
9, 16, 17, 18, 19..	Prickly pear and meal ..	S. equivalent ..	1,014·97	..	1,111·74	2,126·71
		Dig. protein ..	32·68	..	316·65	339·33
	Prickly pear, hay, and meal	S. equivalent ..	668·05	238·40	1,218·52	2,124·97
		Dig. protein ..	25·79	15·59	342·11	383·49
Group 3—						
1, 4, 6	Prickly pear, hay, and meal	S. equivalent ..	281·19	174·82	628·20	1,084·21
		Dig. protein ..	9·02	10·58	178·38	197·98
	Hay and meal	S. equivalent ..	..	414·22	649·00	1,063·22
		Dig. protein ..	..	27·09	182·23	209·32

On the showing of Table 12, the hay rations supplied protein a little more liberally, but all the rations are comparable in this regard.

THE COMPARATIVE VALUE IN MILK PRODUCTION OF PRICKLY PEAR AND SOUDAN GRASS HAY.

Woodward, Turner, and Griffiths estimated the relative values of prickly pear and sorghum hay for butter-fat production in rations producing approximately equal body-weight gains, disregarding the utilisation of portion of the ration for

production of body-weight increase. Their method was essentially to divide the weights or nutritive values of each feed by the weight of butter-fat produced. For the production of 1 lb. of butter-fat they were thus able to show in the various rations that a certain quantity of hay or prickly pear, proportional to their values for production, and equal quantities of grain were required.

By a similar method applied to the data for Groups 1 and 3 (Table 12), the author obtained the figures shown in Table 13 :—

TABLE 13.—STARCH EQUIVALENTS FOR PRODUCTION OF ONE POUND OF BUTTER-FAT AND ACCOMPANYING INCREASE.

—	Ration.	Prickly Pear.	Hay.	Meal.	Gains.
		Lb.	Lb.	Lb.	Lb.
Group 1	Prickly pear and meal ..	7·32	..	7·37	·27
	Hay and meal	..	4·06	7·24	·28
Group 3	Prickly pear, hay, and meal ..	3·48	2·16	7·78	·39
	Hay and meal	..	4·90	7·67	·44

It was thought, however, that the roughages could be better compared if the rations provided only for maintenance and milk-production without body-weight increase, and the figures were subsequently adjusted by subtraction from the nutrients of the roughage feeds of amounts adequate to the gains noted.* In addition, on the assumption that the nutrients of the hay and meal were of equal value in the rations, the slight inequalities of the quotients for meal have been smoothed out by conversion of the excess in one of the pair of meal quotients to hay nutrients. By this method of procedure there were obtained the following results, which are thought to be at least as accurate as those of Woodward, Turner, and Griffiths, viz. :—

Prickly pear fed as sole roughage (high amounts), 7·32 lb. starch equivalent prickly pear = 3·90 lb. starch equivalent hay; or 1·88 lb. starch equivalent prickly pear = 1·00 lb. starch equivalent hay.

Prickly pear fed as part roughage with hay (medium amounts), 3·48 lb. starch equivalent prickly pear = 2·39 lb. starch equivalent hay; or 1·41 lb. starch equivalent prickly pear = 1·00 lb. starch equivalent hay.

* Viz., 3·0 starch equivalent for 1 lb. body-weight increase (6, p. 198).

On the basis of butter-fat production, Woodward, Turner, and Griffiths found that, for *O. gommei* and *O. cyanella*, one part digestible nutrients of sorghum hay equalled 1·4 parts digestible nutrients prickly pear when fed in medium amount; while when fed in high amount the value of the prickly pear was 33 per cent. lower.

As milk is generally valued as a commodity on butter-fat content, the butter-fat basis is no doubt the best on which to evaluate the feeds. If compared on the basis of milk produced, having no regard to fat content, the comparative values of prickly pear and hay will be slightly more favourable to prickly pear. In terms of weights of the feeds, 1 lb. of chaffed Soudan grass hay in rations for milch cows is equal in value to 5 to 6 lb. of succulent prickly pear (85 per cent. water content) when the prickly pear is fed in medium amount, and to 8 lb. when fed in high amounts.

The Influence of Prickly Pear on Composition of Milk.

Feeding prickly pear reduces the fat content of the milk; generally the higher the amount fed, the greater the reduction. (Table 10.) Table 14 gives the fat percentage of the milk of individual cows receiving various feeds in the course of the trials. Table 15 also shows the effect of prickly pear by comparing the fat content of the milk of individuals just before and after changes of roughages:—

Table 14.—Butter-fat in Milk of Individual Cows during Diverse Feeding.

Nos. of Cows.	Ration.	Fat.	Ration.	Fat.
		Per cent.		Per cent.
10	Prickly pear and meal ..	5·70	Hay and meal	6·16
11	..	4·39	..	4·52
12	..	3·49	..	3·74
13	..	4·15	..	4·88
14	..	4·07	..	4·79
9	Prickly pear and meal ..	3·37	Prickly pear, hay, and meal	3·90
16	..	3·38	..	3·98
17	..	5·34	..	5·20
18	..	4·22	..	4·14
19	..	4·06	..	4·34
1	Prickly pear, hay, and meal	4·17	Hay and meal	4·33
4	..	4·32	..	4·69
6	..	3·43	..	3·75

TABLE 15.—FAT PERCENTAGE IN MILK FOR TEN-DAY PERIODS BEFORE AND AFTER CHANGE OF ROUGHAGE.

Nos. of Cows.	Roughage.	Fat.	Roughage.	Fat.
		Per cent.		Per cent.
10	Prickly pear—hay ..	5·97–6·10	Hay—prickly pear	6·52–5·55
11	..	4·14–4·99	..	5·68–4·99
12	..	3·58–3·68	..	3·98–3·75
13	..	3·85–4·76	..	5·01–4·52
14	..	4·18–4·97	..	4·85–4·18
9	Prickly pear — part prickly pear	2·95–3·94	Part prickly pear—prickly pear	4·15–3·91
16	..	3·05–3·94	..	4·03–3·94
17	..	5·22–5·02	..	5·48–5·90
18	..	3·89–4·03	..	4·18–4·66
19	..	4·01–4·02	..	4·64–4·43
1	Part prickly pear—hay	4·10–4·11	Hay — part prickly pear	4·42–4·02
4	..	4·44–4·77	..	4·80–4·46
6	..	3·18–3·67	..	3·93–2·93

A similar reduction of butter-fat content was shown to attend the feeding of prickly pear in the Brownsville trials (9).

As already shown, the inclusion of prickly pear in the ration of dairy cows does not influence the percentage of solids-not-fat of the milk.

THE INFLUENCE OF PRICKLY PEAR ON THE QUALITY OF THE PRODUCT.

No characteristic flavour was found to be imparted to the milk of the cows by feeding prickly pear. Tested for keeping properties in comparison with milk produced on hay roughage, no distinction could be drawn with regard to the rate or condition of souring of the samples. The cream from the milk of prickly pear fed cows could be churned without difficulty. The butter, in contrast to the highly coloured product obtained by Woodward, Turner, and Griffiths, was paler than that produced on the hay roughage. It was judged by the Government dairy expert to be not inferior to the butter produced by hay fed cows.

The milk of prickly pear fed cows seemed to be entirely suitable for cheesemaking. The time of coagulation was normal, and the curd displayed no property that would be unfavourable to manufacture.

THE SUITABILITY OF PRICKLY PEAR AS A ROUGHAGE FOR DAIRY COWS.

Prickly pear is an entirely wholesome roughage for dairy cows, and can be safely fed for considerable periods. All the

cows increased in weight during the trials, and were in satisfactory condition at the conclusion. Cows 5 and 15 received a ration of prickly pear and meal continuously for 140 days. Cow 5 averaged 24½ lb. milk per day at the beginning, and finally 9 lb. per day; during the period she yielded 1,926¼ lb. of milk, containing 77·26 lb. of butter-fat. Cow 15 gave 2,634½ lb. of milk and 96·67 lb. of butter-fat; at the beginning her yield was 26½ lb. of milk per day, and finally 17 lb. Both increased in weight during the period.

Three other cows which were advanced in calf dried off early and were each given 2 to 3 lb. meal per day with 70 to 80 lb. of prickly pear. They remained in excellent condition and subsequently gave birth to well-formed and vigorous calves.

The amount of succulent prickly pear eaten by cows receiving a liberal allowance of meal was about 60 lb. per day. The appetite of dairy cows for prickly pear is somewhat better than that of steers, and is better maintained when other feeds are liberally supplied. Nevertheless, as with steers, when the amounts of supplementary feeds are increased the amount of prickly pear consumed, even when the total feed given is still below the capacity of the cow, is progressively diminished.

This fact, evidence of at most medium palatability of prickly pear, in conjunction with the inferior value of prickly pear nutrients for milk production, would render prickly pear rations, employing prickly pear in high or medium amounts, inadequate to maintain the full milk supply of high-yielding cows. When amounts of meal are given to provide for high milk yield, the amount of prickly pear taken will be small, and the total ration inadequate to the yield. It is thought that prickly pear and meal rations, containing prickly pear as the sole roughage or in such amounts as might be fed with a part roughage of hay, will not generally provide for yields of more than 2½ gallons of milk per day. The supplementation of prickly pear with legume hay in lieu of meal will, on account of greater restriction of appetite for prickly pear due to the bulkier feed, provide only for a lower level of milk yield.

Owing to the greater reduction of butter-fat and depression of milk yield produced by feeding in high amount and as the sole roughage, it would be better to make the prickly pear part of the roughage ration with hay. So fed, prickly pear

appreciably increases the milk yield as compared with an entire hay roughage. Under circumstances where the accompanying depression of butter-fat content is not important, the inclusion of the succulent in the dietary of medium-yielding dairy cows would be an advantage.

PART III.—PRICKLY PEAR IN THE MAINTENANCE OF SHEEP.

Cacti, cut by the machettes of ranchmen, in conjunction with browse afforded by edible bush, are reported to be serviceable as a drought feed for sheep in Texas, while the succulence of the plants in the Mexican desert is said to enable flocks to remain as long as sixty days unwatered (2). Locally *O. inermis* in pasture has been regarded as of no value as sheep feed, the animals either being injured by the prickle or becoming addicted to fruit-eating with fatal results. The object of the experimentation with sheep was to determine the value of prickly pear as a maintenance feed when fed after preparation.

Experimental.

The sheep utilised were lightly woolled store six-tooth ewes, crossbreds or merinos. The prickly pear was of 83-85 per cent. water content, sliced by machine and further finely minced by hand implements. The prickly pear was variously supplemented. The arrangement of the experiment is shown in Table 16 :—

Table 16.—Feeding Trials with Sheep.

Experiment.	Duration.	Number of Sheep.	Supplementary Feeds. Lb. per head daily.
1	20 days	20	Nil
2	60 days	8	·64 lb. wheat bran
3	..	10	·30 lb. linseed meal
4	..	10	·80 lb. chaffed hay
5	..	9	·33 lb. linseed meal
6–10	70 days	7–10	·47–·55 lb. chaffed hay, ·09–·11 lb. blood meal

The total time for which the sheep were fed prickly pear was five months.

The sheep were fed by groups in wooden troughs, and no other feed was available than was given. The animals were

provided with salt and sulphate of iron licks. The average amounts of prickly pear eaten per head daily, the nutrients of the rations, and the daily gains recorded in the experiments are given in Table 17 :—

TABLE 17.—PRICKLY PEAR CONSUMED, NUTRITIVE VALUE OF RATIONS, AND BODY WEIGHTS.

Experiment.	Prickly Pear. Average per Head daily.	STARCH EQUIVALENT.		AVERAGE BODY WEIGHTS.		
		Prickly Pear.	Total.	Initial.	Final.	Gains.
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
1	3·82	·31	·31	88·1	81·6	—·32
2	3·10	·26	·57	80·5	80·2	0
3	2·91	·25	·49	84·0	83·6	0
4	3·21	·26	·57	88·1	88·5	0
5	3·70	·30	·56	68·6	73·2	·09
6	2·08	·17	·43	84·2	80·2	—·06
7	1·80	·15	·41	78·3	70·2	—·11
8	2·64	·22	·46	86·8	81·7	—·07
9	2·10	·18	·44	84·8	76·2	—·12
10	2·80	·24	·46	68·0	67·8	0

The amount of digestible protein in the average prickly pear ration in Experiment 1 was ·01 lb.; the amounts in Experiments 2 to 5 ranged from ·05 to ·09 lb.; in Experiments 6 to 10, ·09 lb. The gains shown are the averages in the groups; at the same time it was apparent that some sheep did better than others. The differences would be accounted for by differences in appetite for prickly pear. Two sheep in Experiment 2 and one in Experiment 3 ate so little prickly pear that it was necessary to remove them to other feed.

The proportion of the total nutrients furnished by prickly pear in Experiments 2 to 5 was about 50 per cent.; in Experiments 6 to 10, 40 to 50 per cent.

The average rations in Experiments 2 to 5 were sufficient to enable the sheep to maintain their condition. In Experiments 6 to 10 the sheep did less well owing to the lower appetite displayed for prickly pear.

THE APPETITE OF SHEEP FOR PRICKLY PEAR.

Prickly pear is indifferently palatable to sheep. It was found that as the amounts of supplementary feeds were increased the amount of prickly pear consumed was pro-

gressively decreased, and when about ·7 lb. starch equivalent was given per sheep in the form of other feeds practically no prickly pear was eaten.

Watering inhibits the consumption of prickly pear by sheep. In Experiments 1 to 5 in winter it was not deemed necessary to water the sheep, save at infrequent intervals, and the prickly pear eaten was higher than in the later experiments, during which warmer weather necessitated watering at least each fifth day. On days on which water was given the sheep ate less prickly pear. The average prickly pear consumption per head on days on which the sheep had no water was ·28 lb. starch equivalent; when water was given, it receded to ·14 lb.

The Limited Utility of Prickly Pear as Sheep Feed.

The indifferent palatability of prickly pear will limit its usefulness to that of an emergency drought fodder for the maintenance of mature sheep; for which purpose it will be a safe and economical feed and may compose up to 50 per cent. of balanced rations, in which it is included. The failure noted of a few sheep to subsist thereon does not affect the general conclusion as to the utility of prickly pear for maintenance; and even the reduced rations, due to occasional watering in warmer seasons, would enable the animals to subsist, or preserve a lean condition, over considerable periods. It will be evident that, for the best results with prickly pear, sheep should be given water as infrequently as the season permits.

The author is of opinion that prickly pear where it occurs might advantageously be made a portion of a drought ration with the edible shrub commonly cut for sheep. The succulence of the plants would tend to conserve water supplies, and would provide a corrective to the fibrous and astringent foliage which may be productive of impaction and losses from this cause.

Prickly pear is not sufficiently palatable to be included in rations designed for fattening or adequate to the maintenance of milk yield of ewes with lambs at foot.

A separate trial showed prickly pear to have no utility as a feed for lambs. The animals ate little, and, when supplied liberally with other feeds, refused prickly pear altogether.

SUMMARY AND CONCLUSIONS.

The prickly pear employed in trials with steers, dairy cows, and sheep was *O. inermis*, a prickly but comparatively spineless species. It was fed after slicing, and no other preparation was necessary.

Prickly pear is a wholesome cattle feed, but alone will not enable cattle to subsist for more than limited periods.

Prickly pear is not highly palatable to steers. With minimum amounts of meals or legume hay, however, steers will generally eat enough to obtain a total ration somewhat more than sufficient for maintenance.

The almost medium palatability of prickly pear will make it useful chiefly in maintenance rations. On account of the little appetite shown for prickly pear when supplementary feeds are given liberally, economic fattening of steers would not be possible on rations employing prickly pear.

No form of prickly pear is markedly more nutritious or palatable than others.

The requirements for the thrift of cattle at prickly pear agistment are edible prickly pear—the form free from prickle—and edible shrub. The best browse afforded by prickly pear and shrub will generally provide only for the turning out of cattle in at most good store condition.

The succulence of prickly pear will satisfy the water requirements of cattle in cool seasons. In drought during hot weather water supplies will be necessary.

Prickly pear is not highly palatable to dairy cows.

Feeding prickly pear reduces the yield of butter-fat and the percentage of butter-fat in the milk. The higher the amount of prickly pear fed in the ration, the greater the reduction. The content of solids-not-fat in the milk is not affected by feeding prickly pear.

Feeding prickly pear slightly increases the milk yield. The increase is more marked when prickly pear is fed in medium amounts than when it constitutes the sole roughage.

The nutrients of prickly pear have less value in milk production than have the nutrients of hay.

Compared with succulent prickly pear, 1 lb. of Soudan grass (*Sorghum* var.) hay was equal to 5 to 6 lb. of prickly pear when the prickly pear was fed in medium amount, and to 8 lb. of prickly pear when given in high amount. It will be better to feed prickly pear as part roughage with hay than as the sole roughage and in high amount. Where reduction of butter-fat is not important, prickly pear would be useful as a succulent in the dietary of milch cows.

Owing to reduction of the amount eaten through feeding high amounts of supplementary feeds, it will not be possible to include prickly pear in high or medium amount in the rations of more than medium-yielding cows.

The butter produced by prickly pear fed cows is pale in colour. The milk is suitable for cheesemaking.

Prickly pear can well constitute the bulk of the ration of dry cows.

It is thought that *O. inermis* is less palatable to cattle than some other species.

Prickly pear is indifferently palatable to sheep. It can be fed finely cut without ill effect.

With small amounts of other feeds enough prickly pear is generally eaten to constitute a ration that is barely sufficient to maintain the sheep.

The succulence of prickly pear will supply sheep with sufficient water in cool weather. The appetite of sheep for prickly pear is diminished when water is given. For the best results the animals should be watered only as made imperative by the season.

The utility of prickly pear for sheep is solely as a roughage in rations for maintenance. It will have no value in sheep-raising.

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THE PHYLOGENETIC SIGNIFICANCE OF THE PREHALLUX AND PRE-POLLEX: A THEORY.

By C. D. Gillies, M.Sc., and P. W. Hopkins, M.C.

(Plate I.)

(*Read before the Royal Society of Queensland, 27th June, 1921.*)

One of the most conspicuous discontinuities in the accepted evolutionary scheme of the Tetrapodal Vertebrata lies between the Fish on one hand and the Amphibia on the other; this hiatus is accentuated by the almost dramatic appearance of the pentadactyl limb, or cheiropterygium, in its typical form in the earliest known Tetrapoda, i.e. the Stegocephalia, and, to add to the obscurity, embryology has thrown but little illumination upon the derivation of the appendage from the Fish limb or ichthyopterygium.

Those fish which are regarded as being nearest the Tetrapoda, such as the Dipnoi and Crossopterygii, possess pelvic and pectoral appendages typically piscine, whereas the most primitive Amphibia are provided with limbs constructed upon the pentadactyl plan, in common with the higher Tetrapoda. Omitting the girdle, the cheiropterygium in its typical form is usually resolved into five parts, viz. :—

(*a*) A proximal single long bone (e.g. femur);

(*b*) A set of two long bones (e.g. tibia and fibula), which articulate with

(*c*) A series of small bones (e.g. tarsalia), followed by

(*d*) A set of five small elongated bones (e.g. metatarsals), supporting

(*e*) Phalanges of the digits.

For a considerable period all the metacarpals and metatarsals were regarded as being serially homologous in each instance, but it has been subsequently shown that the so-called first metacarpal and metatarsal are both homologous with phalanges. This being so, the question suggests itself, What has happened to the true first metacarpal and metatarsal? The fate of these structures has engaged our attention for some time and, as a result, in this paper is presented a theory which we hope will satisfactorily explain the disappearance of these bones.

So far as we can ascertain from the available literature we believe that we have not been anticipated in our views.

THE PHALANGEAL AFFINITIES OF THE FIRST "METACARPAL" AND "METATARSAL."

In the ontogeny of the human metacarpus and metatarsus, it is found that each bone arises from two centres, a primary and a secondary. From the first develops the corpus or body of the bone, while from the second arises the épiphysis. In regard to the second-fifth metacarpals and metatarsals, the epiphysis is situated distally, but in the case of the first metacarpal and metatarsal the epiphysis is proximal—a feature characteristic of the phalanges. In addition to the method of ossification there is the nature of the vascular supply. The nutrient canal in both the phalanges and the first metacarpal and metatarsal is directed towards the capitulum or "runs from the elbow"; this is the reverse of that which occurs in the remaining metacarpals and metatarsals.

After taking everything into consideration, the "metacarpal" and "metatarsal" of the thumb and big toe, respectively, show such convincing phalangeal affinities that they are now almost universally regarded by anatomists as being homologous with phalanges, but on account of their analogy with the series associated with them, as well as for convenience, their names have not been changed.

The theories relating to the subject may be grouped under three headings as follows :—

(*a*) Three phalanges present, metacarpal (or metatarsal) absent ;

(*b*) Two phalanges present, metacarpal (or metatarsal) present ;

(*c*) Two phalanges present, proximal component a phalango-metacarpal (or phalango-metatarsal).

Of these the first is the most generally accepted and it is the one supported by the authors. With reference to (*b*) and (*c*), G. M. Humphrey, in 1858, practically combined these two views, as he regarded the bone in the hand articulating with the multangulum majus (trapezius) as intermediate between a phalanx and a metacarpal, but on the whole he considered that it showed more affinities with the latter ; furthermore he was of the opinion that the missing phalanx is the second.

Wood-Jones (1920) favours the theory of regarding the first element of the first digit as the metacarpal or metatarsal, the second as the first phalanx, and the third as the fused second and third phalanges.

The validity of the epiphyseal argument has been questioned by Allen Thomson (1868, pp. 133-144), who pointed out that the absence of a distal epiphysis in the first "metacarpal" and "metatarsal" is not constant, as there is an occasional appearance of an accessory distal epiphysis in both these bones in man, and to a lesser degree accessory epiphyses may be present in the remaining metacarpals and metatarsals. Thomson showed that these accessory epiphyses are normal in some animals, and are much better developed than in the case of man, viz. :—

(*a*) Distal and proximal epiphyses to all metacarpals and metatarsals, e.g. Ornithorynchus ;

(*b*) Distal and proximal epiphyses in metatarsals, e.g. seal ;

(*c*) Distal and proximal epiphyses to first metacarpal and metatarsal, e.g. koala ;

(*d*) Distal and proximal epiphyses to first metacarpal and metatarsal as an occasional variation, e.g. man.

Thomson summarised the position in a footnote (ibid., p. 143) as follows :—"These observations are interesting when taken along with those that I have recorded on the seal, as confirming the view of the inconstancy of the absence of a distal epiphysis in the first metacarpal or metatarsal bone, and in showing that we must distrust the position of the epiphyses to these bones as the ground of a homological distinction."

Even after rejecting the epiphyseal argument as invalid, in view of Thomson's statements, the nutrient canal has still to be explained. In this worker's paper (ibid., p. 144, fig. 2-4) these are figured antero-posterior longitudinal sections of the first and second digits of the hand and foot of a child seven years of age. Each of the metacarpals and metatarsals possesses both proximal and distal epiphyses, but in regard to the nutrient foramina the direction of the canal—as indicated by bristles—in the first metacarpal and metatarsal is normal, i.e. towards the head of the bone in the typical phalangeal manner ; in the case of the other two bones, the direction of the canal conforms to the true metacarpal and metatarsal type.

Broome (Anat. Anz. 28) favours the view that the proximal position of the epiphysis in the first metacarpal is correlated with the great mobility of the first carpo-metacarpal articulation, i.e. the resemblance to the phalanges is due to convergence.

THE PREPOLLEX AND PREHALLUX.

These terms were given by Bardeleben, in 1885, to accessory bones on the medial side of the carpus and tarsus respectively, which either had previously been regarded as sesamoids or were quite unknown; the terms were first applied to the Mammalia, but it was subsequently shown that they also occurred in the Reptilia and Amphibia. Bardeleben stated (1889, p. 256) that these structures are found in certain members of those orders of Mammalia provided with five functional digits, viz., Marsupialia, Edentata, Rodentia, Insectivora, Carnivora, and Primates. It is of interest to note that Thomson (ibid., p. 139) stated that in those animals having fewer than five digits (e.g. pig and ruminants) only distal epiphyses are present in the metacarpals and metatarsals.

Bardeleben regarded the prepollex and prehallux as representing a degenerate sixth digit in the manus and pes respectively; he also believed that the pisiform and the tuberositas calcanei represented a seventh digit, thus advocating heptadactyly for the cheiropterygium. Gegenbaur attacked these views, which resulted in Bardeleben re-examining his theory, but he re-affirmed it unchanged. Theories relating to hexadactyly and heptadactyly have never received much support, which largely explains their comparative obscurity. Notwithstanding this, however, it is probable that, in the evolution of the cheiropterygium from the ichthyopterygium, polydactyly was characteristic of the early stages, but the pentadactyl scheme must have become stereotyped very early in the history of the Tetrapoda, as at present there is not sufficient evidence to make ancestral polydactyly more than an hypothesis. Baur (1896, p. 669), in commenting on the subject, remarked: "It is the general opinion that the ancestry of the vertebrates with a cheiropterygium had numerous digits, and there was considerable talk of an original hexa- or heptadactylism. No support to this view is given by the Stegocephalia: here we never have more than five digits, very often only four, and entirely limbless forms are found even in the Carboniferous."

Again, Beddard (1902) is not a supporter of polydactyly, as he regarded the prepollex and prehallux as accessory ossifications. Bardeleben (1889) described a nail associated with the prepollex of the Cape jumping hare (*Pedetes capensis*), and used the fact of the presence of such a structure with the prepollex and prehallux as an important argument in favour

of his theory, but Beddard (ibid.) showed that it loses weight when it is remembered that the marsupial genus *Onychogale*, or nail-tailed wallaby, possesses a nail-like appendage on the extremity of its tail; the lion is also similarly provided.

As mentioned above, Palæontology does not support the theory of polydactyly, as the Stegocephali hitherto discovered are never provided with more than five digits to the pes or manus, and furthermore some of them may even be apodous. In this connection Wood-Jones (1920, p. 16) states: "It is true that Palæontology has proved that the digitate limb may possess more than five digits, but that is a very different thing from demonstrating that any number greater than five represents a basal or primitive condition, for it is possible that the increased number might be due to a secondary specialisation."

Embryology is equally silent. In the development of the Amniote limb, never more than five digits have been observed in normal cases, and all the digits appear simultaneously. Frequently more digits are present in the embryo than in the adult, as, for example, in the Aves a rudiment of the fifth toe may arise in the embryo, but it degenerates later and is absent in the adult; this, of course, being in accordance with the Law of Recapitulation. In the tailed Amphibia the development of the digits proceeds in a different manner, the process being one of budding. The first to appear are the first and second digits, then the third, fourth, and fifth in order; and according to Baur there are never more digits in the embryo than in the adult. Graham Kerr also states that there is a tendency for the digits of Amphibia to develop in regular sequence according to the number of digits in the adult. On the other hand, it must be mentioned that Bardeleben (ibid., p. 256), stated that Kehrer maintains there is evidence for believing heptadactyly occurs in the Urodela.

In the Reptilia the prepollex and prehallux do not appear to be well represented, but in the Amphibia Anura the prehallux is quite a conspicuous structure.

The Prepollex and Prehallux as the Missing Component in the Pollex and Hallux respectively.

Baur has suggested (1896, p. 669) that the prepollex and prehallux are of secondary origin, but, as Comparative Anatomy, Palæontology, and Embryology do not support theories of

primitive hexadactyly or heptadactyly within known geological times, it does not appear tenable to regard either of these bones as accessory digits. Again, there is not a tendency for the addition of digits ; on the contrary, there is a pronounced movement towards reduction, and Flower (1885, p. 283) has summarised the manner of reduction as follows :—When one digit is lost, it is usually the first, then follows the fifth ; the third is always retained though either two or four or both of these digits may be absent.

Graham Kerr (1919, p. 453), in commenting upon the cheiropterygium, considers that there is greater anatomical efficiency in the possession of a central digit supported on each side by another digit ; and possibly the presence of an additional digit outside these again is a further advantage. This then implies that the third digit is the most essential of the series, a conclusion quite in accord with Flower's Law of Digital Reduction.

As nature seems so insistent upon the expression of symmetry, to obtain this state of affairs with a six-digital manus or pes it would necessitate shifting the axis of symmetry from the third digit to the interval between the third and fourth. This may appear to be the case in regard to the Artiodactyle Ungulates (e.g. pig), but when the carpus and tarsus are considered it will be seen that the symmetry of the appendage is fundamentally of the pentadactyl type, and that the shifting of the symmetry of the digits to the interval between the third and fourth is quite secondary, and only applies to the digits themselves.

With reference to the Anuran prehallux, Gadow (1901, p. 20) states that there are "five toes and the rudiment of a sixth digit, the so-called prehallux, which consists of two to four pieces, including the one representing the metatarsal. This prehallux as a vestige of a once better developed digit is exactly like the elements on the radial side of the wrist which, we are certain, are the elements of a once complete finger, the pollex. The only weighty difficulty against its interpretation as a prehallux lies in the fact that hitherto no six-toed Stegocephali have been found, but the fact that none are known with more than four fingers could be used as an argument against there being a pollex in recent Anura with just as good reason."

Gadow's argument with reference to the pollex and four-fingered Stegocephali is invalid, for five-fingered forms are known, e.g. *Keraterpeton crassum* (Zittel, 1902, p. 127) has five digits in both manus and pes.

Beddard's suggestion regarding the prepollex and prehallux as being accessory ossifications cannot apply to the Anura, as such ossifications are not at all typical of the Amphibia. The most characteristic accessory ossification in the Tetrapoda is the pisiform of the carpus—a bone which does not typically appear until the Reptilia are reached.

In connection with this paper, we examined, by means of X rays, the pes of the following Anura :—*Adelotis brevis, Hyla cœrulea, H. peronii, Limnodynastes tasmaniensis, Notaden bennetti*, and *Rana papua*. From the plate it will be observed that there is no trace of the prehallux in *H. peronii, N. bennetti*, and *R. papua*, while in the remaining species a prehallux is present lying on the medial side of the pes near the tarsometatarsal articulation ; in *A. brevis* and *H. cœrulea* it consists of two components and maybe in *L. tasmaniensis* also, though in regard to the latter the prehallux may prove to be only a single bone.

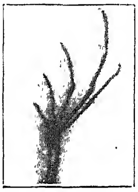
In most textbooks it is usually stated that the prehallux of the Anura consists of three or four pieces, of which the proximal member represents the metacarpal, and the remaining segments, the phalanges.

After carefully considering the data we advance the theory, *that the prepollex and prehallux are the degenerate remnants of the true first metacarpal and metatarsal of the manus and pes respectively*. We also regard the frequent occurrence of the prehallux in the Anura as a point of conciliance in favour of our theory, for by the Law of Recapitulation traces of the missing first metatarsal (and metacarpal) might be expected to occur in the Amphibia, which are almost universally considered to be the parent stock of the Tetrapoda. We consider that the pentadactyle condition became stereotyped very early in the history of the Tetrapoda, and that in these early forms all the digits were provided with true metacarpals or metatarsals as the case may be (*see* Fig. C). It is interesting to note that Bateson (1894) mentions a number of cases of variations in the human hand in which the thumb is provided with three phalanges—a condition which may be regarded as a reversion to the primitive type. Furthermore, it is significant

PLATE I.

A. Rana papua.

B. Hyla cærulea.



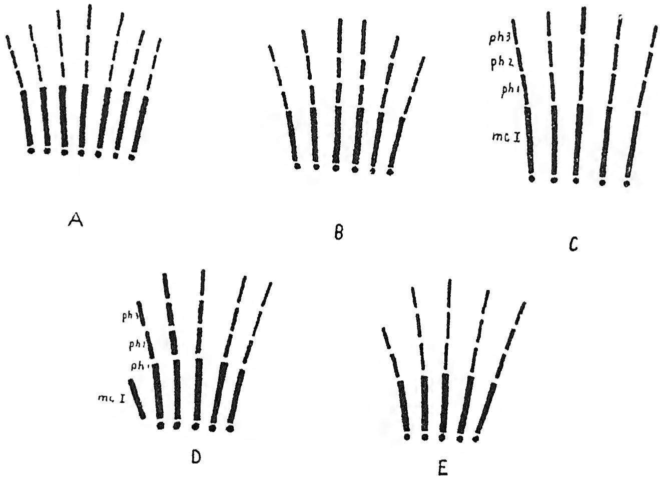
C. Limnodynastes tasmaniensis.

D. Notaden bennetti.

E. Hyla peronii.

F. Adelotis brevis.

Radiographs of the Anuran Pes.



Diagrams illustrating the fate of the first Metacarpal and Metatarsal according to the Prehallux Theory.

A, B. Hypothetical hepta- and hexadactyle stages, of which *A* is more primitive than *B*. Probably, in each instance, some of the digits were provided with more than three phalanges.

C. Primitive pentadactyl condition.

D. Metacarpal (or metatarsal) of first digit displaced = prepollex (or prehallux).

E. Typical pentadactyl manus (or pes).

mc 1. First metacarpal or metatarsal. In *D* it represents the prepollex or prehallux.

ph 1, *ph* 2, *ph* 3, First, second, and third phalanges respectively.

that, though an accessory phalanx may occasionally occur in the thumb, the number of phalanges in the fingers, on the whole, is remarkably constant.

Later, in the course of evolution, the true first metacarpal and metatarsal became displaced and subsequently disappeared in the great majority of Tetrapoda. Its occurrence in the Amphibia is therefore correlated with the lowly position of the group, while its appearance in animals such as *Talpa* and *Pedetes* may either be due to persistence or atavism. The multiple condition of the Anuran prehallux we regard as the result of fragmentation consequent upon the degeneracy of the structure and the mobility of the pes.

RECAPITULATION.

After examining the available literature, and from a consideration of the material investigated, we summarise as follows :—

(*a*) The first metacarpal and metatarsal of the manus and pes are serially homologous with phalanges.

(*b*) In spite of the fact that the epiphyseal argument in favour of the phalangeal nature of the first metacarpal and metatarsal loses weight on account of the normal presence of distal and proximal epiphyses to these bones in certain animals, e.g. Koala, we consider sufficient evidence still remains to regard the first metacarpal and metatarsal as phalanges.

(*c*) Heptadactyly and hexadactyly, which probably may have occurred in the earliest Tetrapoda, cannot be regarded at present as more than philosophical speculations ; pentadactyly appears to be firmly established throughout the known Tetrapoda, both living and extinct.

(*d*) The prepollex and prehallux are regarded by the authors as representing the missing first metacarpal and metatarsal respectively.

ACKNOWLEDGMENTS.

In conclusion, we desire to express our indebtedness to Professor R. Berry, University of Melbourne, for his sympathetic interest and advice ; also to Mr. H. A. Longman, F.L.S., Director of the Queensland Museum, for the use of valuable material ; and to Mr. W. M. Tanner, Brisbane, who generously undertook the preparation of the X-ray photographs used in this investigation.

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ACACIAS OF SOUTH-EAST QUEENSLAND.

By John Shirley, D.Sc., and C. A. Lambert.

(Plates II-VI.)

(Read before the Royal Society of Queensland, 27th June, 1921.)

1.—INTRODUCTION.

To the Australian, the native wattles, forming his national emblem, possess a sentimental interest. To the general botanist they are none the less interesting, presenting striking peculiarities in their adaptation to climate. Many species use their flattened leafstalks or phyllodes to play the part of leaves after the seedling stage is passed, and these phyllodes bear stomata in almost equal number on both surfaces. The colour attraction for insects is found in the filaments of the stamens and not in the petals. The stamens may have eight spherical chambers for the protection of pollen, instead of the four usually present in flowering plants; and there are no arrangements for protecting the pollen from rain or dew. Another peculiarity is the propagation of many species by means of root-cuttings.

2.—REVIEW.

The following are the common wattles in S.E. Queensland :—

No.	Series.	Scientific Name.	Local Name.
	Uninerves—	*Acacia*—	
1	Brevifoliæ	*plagiophylla* F.v.M.	Transverse-veined wattle
2	Racemosæ	*penninervis* Sieb.	Feather-veined wattle
3	Racemosæ	*falcata* Willd.	Burra
4	Racemosæ	*suaveolens* Willd.	Sweet-scented wattle
5	Racemosæ	*fimbriata* A. Cunn.	Creekside wattle
	Plurinerves—		
6	Triangulares	*amblygona* A. Cunn.	Obtuse-angled wattle
7	Nervosæ	*implexa* Benth.	Curly-fruited wattle
8	Nervosæ	*complanata* A. Cunn.	Winged wattle
	Juliforæ—		
9	Tetrameræ	*longifolia* Willd.	Toowoomba wattle
10	Falcatæ	*maideni* F.v.M.	Maiden's wattle
11	Falcatæ	*glaucescens* Willd.	Rosewood wattle
12	Falcatæ	*cunninghamii* Hook.	Black wattle
13	Falcatæ	*aulacocarpa* A. Cunn.	Hickory wattle
14	Dimidiatæ	*cincinnata* F.v.M.	Island wattle
15	Bipinnatæ	*decurrens* Willd.	Green wattle

Less common, or more local, are *A. pugioniformis* Wendl., *A. hispidula* Willd., *A. amœna* Wendl., *A. adunca* A. Cunn., *A. podalyriæfolia* A. Cunn., *A. elongata* Sieb., &c., &c. The anatomical details, given in this paper, are restricted to Nos. 2, 5, 6, 7, 10, 12, 13, and 14.

3.—GENERAL NOTES.

I.—*Acacia amblygona* A. Cunn. is found in undulating country, and on the foothills of ranges, both in coastal and inland districts. Near Brisbane its height is seldom more than 3 or 4 feet. Its branches are terete and pubescent, and the phyllodes are 3-4 lines by $1\frac{1}{2}$ to 3 lines and almost triangular. The pods are linear, somewhat curved, and $1\frac{1}{2}$-2 lines broad. They are slightly contracted between the seeds. It is figured in Mueller's Australian Acacias, decade 7, plate 3. It has been reported from Eidsvold, Miles, and Chinchilla.

II.—*Acacia aulacocarpa* A. Cunn. is known in South-eastern Queensland as the hickory wattle, as its young stems were formerly used as handles for the whips of bullock-drivers. It is found along the eastern coast of Queensland from the Tweed River to Bowen and Lizard Island,[1] and inland through the Suttor Desert[2] to tropical West Australia.[3] Its phyllodes are similar in general appearance to those of *A. cunninghamii* Hook., from which they can be distinguished, under the lens, by their freedom from anastomoses in the veins, and by their faintly glaucous surface. The pods are 2-$3\frac{1}{2}$ inches long and $\frac{3}{4}$ inch broad, the outer surface marked by oblique furrows, from which the specific name is derived. *Acacia aulacocarpa* grows in communities, forming wattle scrubs, and reaches in S. E. Queensland a height of 20 to 30 feet. It is figured in Mueller's Aust. Ac., dec. 9, pl. 9; and in Maiden's Forest Flora, vol. 3, pl. 103.

III.—*Acacia cincinnata* F.v.M.[4] In the Flora Australiensis this wattle was reported as from "Rockingham Bay and several other localities in tropical Queensland," a statement repeated in Bailey's Queensland Flora, vol. ii, p. 513. Unfortunately Bailey seldom added to the localities given in the Flora. Cambage (Proc. Roy. Soc. N.S.W., vol. 49, p. 396)

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[1] Maiden, Tropical Acacias of Queensland, p. 45.

[2] Maiden, Flora of Northern Territory, p. 327.

[3] Maiden, Notes on Tropical West Australian Acacias, p. 111.

[4] White, Queensland Naturalist, April 1917, p. 65.

PLATE II.

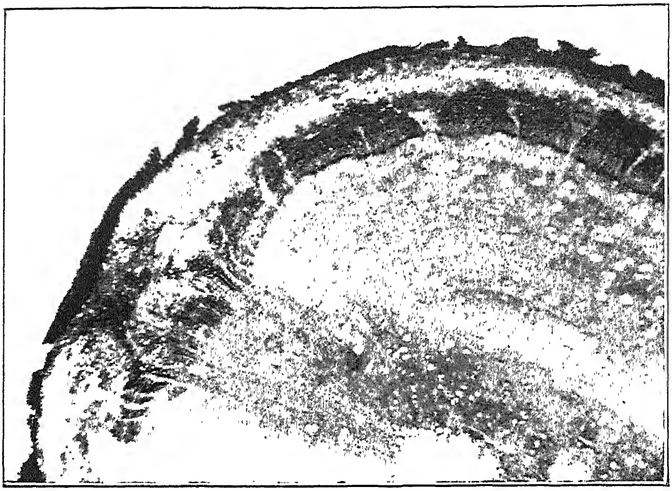


Fig. 1.—*A. amblygona*, T.S., x 25.

a. Pith. *b*. Leaf trace. *c*. Secondary wood. *d*. Bast. *e*. Phelloderm.

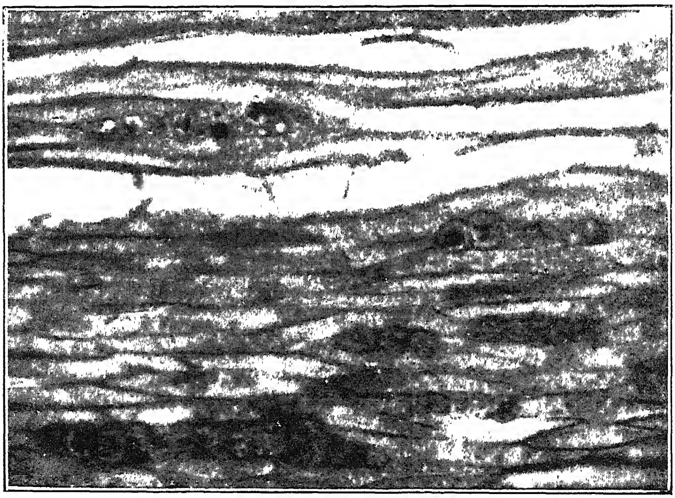


Fig. 2.—*A. amblygona*, L.T.S., x 200.

a. Wood fibres. *b*. Medullary ray. *c*. Tracheides.

PLATE III.

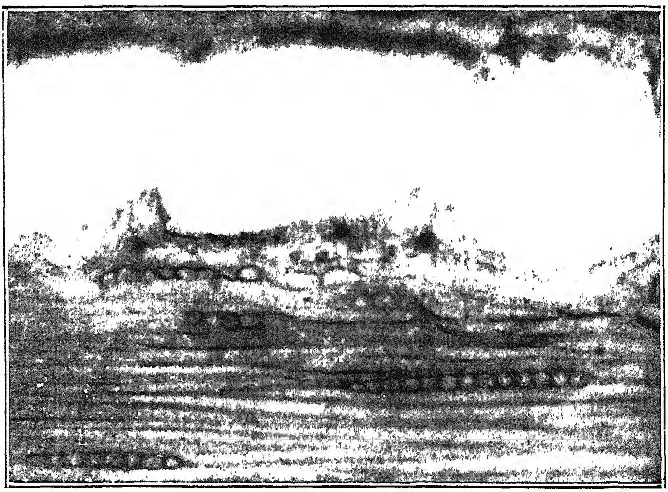
e d c

a

b

Fig. 1.—*A. cunninghamii*, T.S., x 40.

a. Pith. *b.* Secondary wood. *c.* Bast.
d. Phelloderm. *e.* Cork.



c

a

b

Fig. 2.—*A. cunninghamii*, L.T.S., x 200.

a. Wood fibres. *b.* Medullary ray. *c.* Dotted vessel.

gives Kuranda to Almaden in the Cairns hinterland as additional habitats. Recently[5] it has been found on Bribie Island at the northern end of Moreton Bay, growing in swampy ground, and forming tall trees 40 to 50 feet high. Fortunately it was found in fruit, and the curious spirally curled pods were confirmative of its determination. The bark is dark, and at first sight suggests an ironbark eucalypt. This species is figured in Mueller's Aust. Ac., dec. 9, pl. 6. Along the tropical coast it is called the island wattle.

IV.—*Acacia cunninghamii* Hook. was formerly known round Moreton Bay as the black wattle. It grows in the same situations as *A. aulacocarpa*, which it often closely resembles in height and phyllodes. When in fruit it can easily be distinguished by its much narrower pods; when without fruit it can be separated from its ally by the frequent anastomoses of the veins of the phyllodes, and by the triangular outline shown in a cross-section of the young twigs.

V.—*Acacia fimbriata* A. Cunn. is known as the creek-side and flax-leaved wattle, and loves the sides of streams and the borders of marshes, being found in coastal country from Brisbane to Broadsound. It was formerly known and distributed in Queensland as *Acacia linifolia* Willd., from which Mr. J. H. Maiden has shown that it must be specifically separated. The main differences are in the phyllodes, which in *A. fimbriata* are larger, broader, and fringed along the margins with minute cilia. Mr. Maiden[6] has suggested the vernacular name of fringed wattle, leaving that of flax-leaved wattle to the true *A. linifolia*. This species is figured in Forest Flora, vol. v, pl. 157. It is a tall shrub or small tree, seldom reaching 20 feet in height.

VI.—*Acacia implexa* Benth. is found in Queensland from the Brisbane to the Burnett River along the coast, and inland to the valley of the Dawson, the great southern tributary of the Fitzroy. In S.E. Queensland it is typically a mountain species, and is specially characteristic of such basaltic masses as Tambourine, Beech Mountain, and Springbrook. It forms trees reaching 30 or 40 feet or more. The linear pods, not more than 3 lines broad when ripe, form a twisted and curled-up mass, hence the specific name. It is figured in Mueller's Aust. Ac., dec. 8, pl. 2; and in Maiden's Forest Flora, vol. v, pl.

[5] Proc. Roy. Soc. Qd., vol. 27, p. 97.
[6] Forest Flora, vol. v, p. 31.

153. It is known as the mountain wattle and curly-fruited wattle among bushmen and selectors. The flowers are usually of a very pale yellow colour.

VII.—*Acacia maideni* F.v.M. is a common wattle in sandy country near Brisbane. A fine specimen in the Botanic Gardens, Brisbane, is probably a survival from the old river scrub in that locality. When young its phyllodes are often mistaken for those of *Acacia longifolia* Willd. The flowers are in nearly sessile spikes, solitary or two or three together, and are pale yellow or almost white. The pods are narrow and twisted, and may be mistaken for those of *A. implexa*. The flowers closely resemble those of *Acacia longifolia*, from which Maiden's wattle may be separated by not possessing the white bract at the base of each flower, as in *longifolia*. At times the similarity between the phyllodes of *A. implexa* and *A. maideni* is extremely close. No common name is used for this tree in Southern Queensland. It is seldom found more than 20 feet in height; it is figured in Maiden's Forest Flora, vol. vi, pl. 220.

VIII.—*Acacia penninervis* Sieb., the feather-veined wattle, is extremely common in the low-lying coastal country of S.E. Queensland. It is easily recognisable by its pinnately veined phyllodes, the edges thickened, and usually showing a marginal gland below the middle. Each globular capitulum contains about 20 flowers, the calyx truncate, the petals smooth. It extends from Point Danger to Roma and Mitchell, beyond which to the north and west it seems to be replaced by its ally *A. bancrofti* Maiden. It is figured in Maiden's Forest Flora, vol. iii, pl. 91, 92.

4.—HISTOLOGY OF STEMS.

I.—*Acacia amblygona* A. Cunn., transverse section of twig in its third year. (Plate II.) The pith shows large polygonal cells, in transverse section, six- or seven-sided, 20-26 μ in diameter, some having lost their protoplasmic contents, others filled with starch grains, showing radiate arrangement. The medullary rays, coloured by methylene blue, show very plainly, and the cells are large for the Acacia family, measuring 14-20 μ. Through the wood of the first and second years they are in single rank, in the third year's wood they may be in double or treble rows. The vessels of the xylem are smaller

PLATE IV.

Fig. 1.—*A. linifolia*, T.S., x 25.

Pith in centre. *b*. Leaf trace. *c*. Secondary wood. *d*. Bast. *e*. Phelloderm.

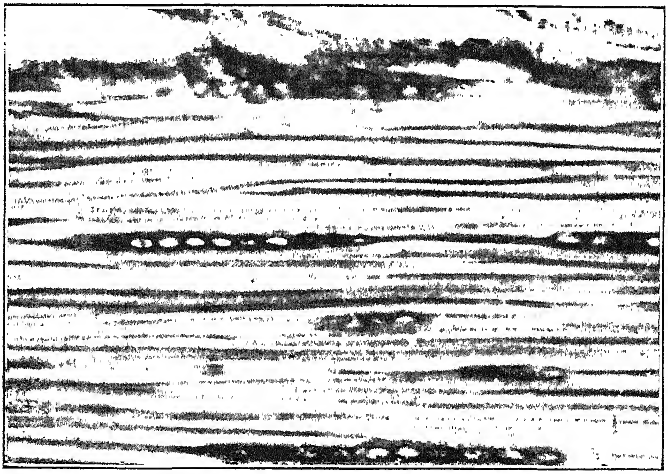


Fig. 2.—*A. linifolia*, L.T.S., x 200.

a. Tracheides. *b*. Wood fibres. *c*. Medullary ray.

than usual, ranging from 30-57 μ in diameter; in all other wattle stems sectioned, the vessels reach usually twice these dimensions. The sieve tubes show the same peculiarity, being decidedly narrow in transverse section. The stem is strengthened by old strands of hard bast, pushed out towards the circumference, to form sclerenchymatous strengthening bands, like the steel laths of reinforced concrete. The phelloderm takes the methylene blue stain very deeply, as does the live cork; between the two is seen the almost unstained phellogen, some of the cells undergoing mitotic division.

In the tangential longitudinal section the same structures are seen, small reticulated vessels and tracheides prevailing throughout a great portion of the xylem, with larger dotted vessels in the sapwood.

II.—*Acacia fimbriata* A. Cunn. and *A. linifolia* Willd. (Plate IV.) No support is given to a separation of these two wattles by a study of their internal structure. The supply and arrangement of the vessels of the xylem agree in both forms; the medullary rays are similarly strongly marked, the pith is larger in area, relative to the wood, than in many allied species, and in tangential section the medullary rays show both in xylem and phloem a single row of elongated oval cells. In the deeper layers of the cortex, strands of sclerenchyma are noted, the cavities of the cells almost obliterated by the addition of layers to the cell-walls. Occasionally these strands invade the outer layers of the alburnum. The larger vessels and tracheides are pitted ones; reticulated vessels are far less numerous than in *A. amblygona.*

In the medullary rays, when passing through the phloem, the cells are shortest in the direction of the ray, the transverse diameter being much enlarged.

III.—*Acacia aulacocarpa* A. Cunn., *A. cincinnata* F.v.M., and *A. cunninghamii* Hook. (Plate III.) These all belong to Julifloræ, and the first and third species have many features in common. In the transverse section of a young twig, the triangular outline at once distinguishes *A. cunninghamii*, but this means of identification is lost in older branches. Vessels of the xylem of *A. cunninghamii* range from 70 μ to 140 μ and are the broadest of any acacia examined; in *A. aulacocarpa* they vary from 30 μ to 105 μ; and in *A. cincinnata* have about the same limits. In the first year's stem of *cunninghamii,*

triangular in outline, the epidermis is well shown, the outer walls so strengthened with cutin as to form half the radial diameter of each cell. A circle of sclerenchyma lies between the phelloderm and the phloem, lying in a series of curves round the vascular bundles, with larger thick-walled cells where two curves meet, some of which have the diameter of vessels. In older sections of 4-5 years, the vessels have their greatest diameter parallel to the circumference, and the lines of wood-cells are much distorted around vessels and near the outer portions of the xylem. The pith-cells are full of starch grains, and a few contain tabulate crystals. In tangential longitudinal section both *aulacocarpa* and *cunninghamii* show the cells of the medullary rays in uniseriate arrangement; in the former the ray sections are 210-225 μ by 9-12 μ; in the latter 110-210 μ by 10 μ. *A. cincinnata* shows alternating layers of hard and soft bast in the phloem, but otherwise its histology is that already described for *aulacocarpa.*

In *cunninghamii* the pith cells are large, filled with starch, often elongated in a radial direction and bounded by a wavy outline of protoxylem. The primary medullary rays are strongly marked, and are formed of cells of considerable radial diameter.

Neither endodermis nor pericycle is clearly shown in any member of this group.

IV.—*Acacia penninervis* Sieb., in transverse section, is remarkable for the numerous broken concentric rings of sclerenchyma or hard bast in the phloem, and for the thickness of the bast layer. The vessels vary in diameter from 43 μ to 105 μ. The wood-cells produced in autumn have their walls much thickened, and each annual zone is thus made to add to the strength and elasticity of the stem. Dotted tracheides are more than usually numerous.

Passing through the phloem, the cells of the medullary rays remain uniseriate, but acquire a greater transverse diameter, and are plainly seen in the more internal masses of sclerenchyma. In tangential section they measure 103-220 μ by 6-17 μ. In the phelloderm, at intervals, the large cells are seen to be placed with the long axis directed radially; in other parts of the inner cortex the longitudinal axis of each cell of this inner layer is vertical. These cells retain their protoplasm, and have a rather narrowly elliptical nucleus. (Plate VI.)

PLATE V.

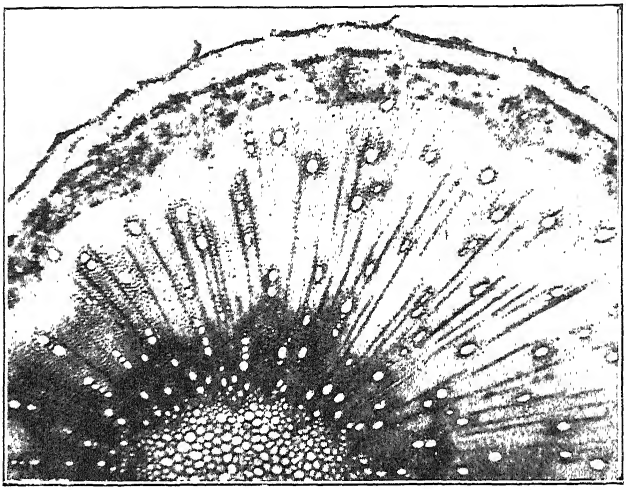


Fig. 1.—*A. maideni*, T.S., x 35.

a. Pith. *b.* Vessel. *c.* Secondary wood.
d. Cambium. *e.* Bast. *f.* Phelloderm.
g. Cork.

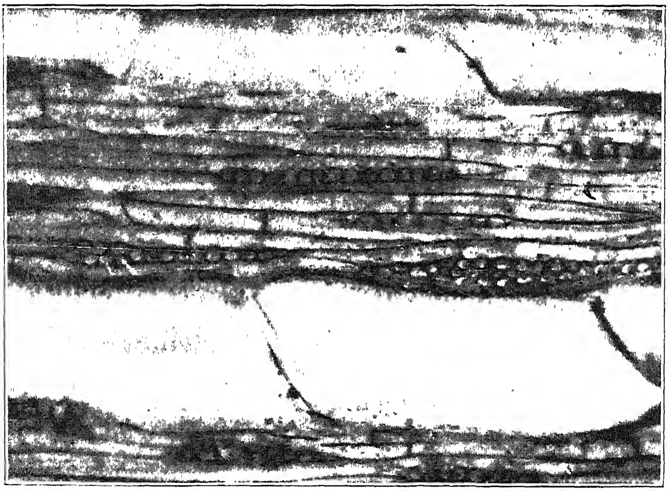


Fig. 2.—*A. maideni*, L.T.S., x 200.

a. Wood fibres. *b.* Tracheides. *c.* Medullary ray.

PLATE VI.

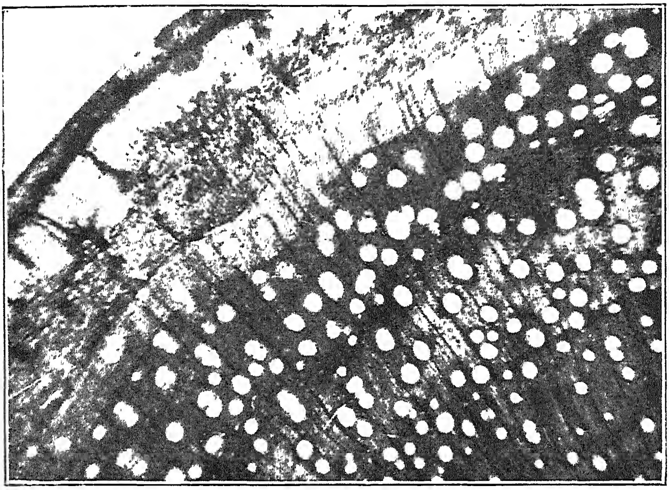


Fig. 1.—*A penninervis*, T.S., x 25.

a. Pith. *b*. Secondary wood. *c*. Cambium.
d. Bast. *e*. Sclerenchyma. *f*. Cork.

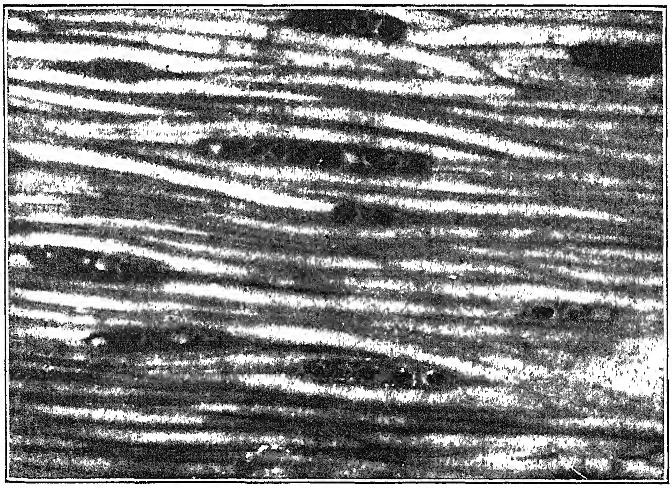


Fig. 2.—*A. penninervis*, L.T.S., x 200.

a. Medullary ray. *b*. Wood fibres.

V.—*Acacia maideni* F.v.M. differs radically in its histology from all other species examined. The vessels of the xylem are few and small, and in young stems all are elongated in a radial direction. The medullary rays are narrow and drawn out radially, and the cells of the wood parenchyma are less thick-walled than usual. Much of the water and dissolved minerals of the ascending sap must pass by osmosis through the wood-cells of the alburnum.

Passing through the phloem the medullary rays take a very wavy course. In tangential section they measure 110-285 μ by 8 to 12 μ. The pith is of the usual structure and contains a few idioblasts. Strands of sclerenchyma are found in the cortex, but this tissue is not as strongly developed as in any of other acacias examined. Surrounding the vessels of the xylem the wood-cells are larger and their rows more irregularly constituted (tangential section) than elsewhere. In the cells of the cortex numerous tabulate crystals were noted. (Plate V.)

VI.—*Acacia implexa* Benth. The young stem of *implexa* 1-2 years old shows the layer of epidermal cells with their external thickening of cutin. The pith and xylem are of the ordinary type, but the phloem is mainly of soft bast, and the sclerenchyma is only moderately developed. In all other respects it agrees with the characteristics already laid down.

NEW AND LITTLE-KNOWN SARCOPHAGID FLIES FROM SOUTH-EASTERN QUEENSLAND.

By Professor T. HARVEY JOHNSTON, M.A., D.Sc., and O. W. TIEGS, M.Sc., Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(Twenty-six Figures.)

(*Read before the Royal Society of Queensland, 27th June, 1921.*)

THE sheep maggot-fly problem in Eastern Australia has led to a considerable amount of attention being paid to certain blowflies, especially in New South Wales where Mr. W. W. Froggatt has been investigating them. However, apart from some references to a few species, e.g. *Sarcophaga aurifrons*, very little notice has been taken of the Sarcophagidæ for many years past. In fact there is not an adequate account of even one of the flesh flies as yet recorded from the Commonwealth. Only two species from Australia have been figured, viz., *S. aurifrons* by Froggatt and *S. pachytili* by Olliff. The family has, then, been almost entirely neglected, this inattention to such a common group of large blowflies being no doubt due to the difficulty experienced by collectors and workers in differentiating the various forms. Commonly Sarcophagid specific characters are far from being obvious, and as a rule it is necessary to study the male copulatory organs in order to differentiate between species which otherwise are very similar. It is extremely difficult to allot female specimens to their species as they much more closely resemble one another than do the males of different species. In order to obtain the two sexes we have bred out specimens from larvæ deposited by captured gravid females. As regards certain of those dealt with by us we have examined only males which were captured, and in such cases the female is still unknown.

The senior author, while on a recent visit to U.S.A. and England, took the opportunity to submit some Queensland Sarcophagids to Dr. J. M. Aldrich, of the National Museum, Washington D.C., and Major E. Austen, D.S.O., of the British Museum. To those two authorities on Diptera we are indebted

for certain identifications referred to later on. Dr. Aldrich also kindly allowed us to make use of the card catalogue of those recorded from Australia, the catalogue being the work of Dr. C. H. Townsend.

The first author to deal with any Australian Sarcophagidæ was Robineau-Desvoidy, who in 1830 published descriptions of five species from Sydney, viz., (1) *S. depressa*, (2) *S. peregrina*, (3) *S. subrotunda*, (4) *S. rapida*, and (5) *S. musca*, all under the generic name *Myophora*. We have not been able to consult his "Essai," but, thanks to Mr. W. A. Rainbow, Australian Museum, Sydney, we have seen figures of *S. musca* published by Guerin-Meneville, whose specimens came from New Guinea. The text relating to the work (Zoology, Voyage of the "Coquille") was not available, but Figure 4 suggests a *Sarcophaga*; the drawing of a front view of the head and face, however, shows marked differences from the *Sarcophaga* type, e.g. the sketch shows the presence of a fully plumose arista, prominent first antennal joint, an atypical number and arrangement of the bristles. If the figure be incorrectly drawn, then it is possible that *S. musca* may be that described later by Walker as *S. irrequieta*, since small underfed specimens of the latter commonly resemble *Musca domestica* at first sight in regard to size and colouration. In all probability the remaining four, if recognisable, will be found to be common forms in the vicinity of Sydney (*S. misera* being one for example), and some of the species described in this paper may be synonyms.

A little later Macquart (1846, 1855) described three from the east coast of Australia, viz., (6) *S. aurifrons*, (7) *S. flavifemorata*, and (8) *S. ruficornis*. The last-mentioned specific name is not available, having been preoccupied by *S. ruficornis* (Fabr.) from East India. No. 7 we do not know. *S. aurifrons* is the name given in Australia to a certain type of blowfly, but as a result of our observations we find that probably ten or twelve Brisbane species could be included under the description. As we have not access to Macquart's type, we have fixed his name on a particular species based on specimens collected in Brisbane by Mr. Froggatt many years ago and forwarded to Washington D.C. for determination by Coquillet, who labelled some as *S. aurifrons* Macq. and others as *S. frontalis* Thoms. Through the kindness of Mr. Froggatt we have been able to examine the determined specimens.

Brauer and Bergenstamm (1891) used the name *S. aurifera* Macq. but we suspect it to be an error for *S. aurifrons*. At any rate it is a mere *nomen nudum* as used by these two authors.

Walker (1849) added the names of four species to the list, viz., (9) *S. impatiens*, (10) *S. misera*, (11) *S. irrequieta*, and (12) *S. prædatrix*. The type specimens of all four species are in the British Museum and are females labelled as having been collected in Sydney, New Holland, Houtman's Abrolhos (West Australia), and Port Essington (Northern Territory) respectively. We are now able to give full accounts of the first three of Walker's species, but the fourth is not represented in our collection.

Thomson in 1868 described two Sarcophagids collected by the "Eugenie" naturalists in Sydney, viz., (13) *S. ochripalpis* and (14) *S. pallichrus*. The former was stated to be near *S. aurata*, a species described by Macquart (locality, ? Oceania); but we have regarded it as a synonym of *S. irrequieta*. *S. pallichrus*, which Van der Wulp placed tentatively in his genus *Sarcophagula* (1887), is not represented in our collection.

There do not appear to be any more references to the group until 1891, when Olliff and Skuse named two parasites of grasshoppers as (15) *Tachina œdipoda* and (16) *Masicera pachytili* respectively. Olliff referred to the latter and published a figure of it (1891a), the illustration being republished by Mackinnon (1920). The species was subsequently stated by Froggatt (1905, 1907) to be a *Sarcophaga*. *Tachina œdipoda* is a *nomen nudum* as far as Olliff (1891b) is concerned, but Froggatt (1905, 1907) has reported it to be a *Sarcophaga*, closely related to *S. aurifrons*. The status of these two flies bred from locusts can only be determined by an examination of the type material.

Certain specimens collected in Brisbane and forwarded by Mr. Froggatt (1907) to Coquillet for determination were reported to be (17) *S. frontalis*. Owing to Mr. Froggatt's kindness we have been able to synonymise Thomson's species with Walker's *S. misera*. Besides, the name *frontalis* is preoccupied, having been employed by Doleschall in 1858.

Information relating to *S. aurifrons* was published by Mr. Froggatt in 1905, 1907, and in 1915.

The last Australian *Sarcophaga* to be described was (18) *S. froggatti* Taylor, 1917. Thanks to Mr. G. F. Hill, of the Australian Tropical Institute, we have been able to give an account of this fly.

Thus, of the eighteen species recorded to date, no less than eleven (including one with a preoccupied name) are still imperfectly known, many of them being quite unrecognisable from the scanty descriptions. Five are fully described (both sexes) in our paper, and two have been reduced to synonyms. To the list we add fifteen new and one previously known species, giving a description of both sexes in the case of eight new ones, and of the male only in the remaining seven.

We have compared our specimens with the accounts of various *Sarcophagas* from New Guinea, Southern Asia, the East Indies, and the Pacific Islands, as given by Walker (1856-1865), Macquart, Thomson, and Parker. Unfortunately many of the descriptions published by Macquart and Walker are so general or so scanty as to be of very little value for comparative purposes. The following species, however, may be definitely excluded from synonymy with the species referred to in this paper :—*S. ruficornis* Fabr. (India and Philippines); *S. orientalis* Parker, *S. crinita* Parker, *S. harpax* Pand. (all from Philippines); *S. perpusilla* Walker (New Guinea); *S. robusta* Aldrich, *S. hæmorrhoidalis* Fallen, *S. barbata* Thomson, *S. pallinervis* Thomson (all from Hawaii); and the following described by Walker from the East Indies: *S. aliena*, *S. indicata*, *S. invaria*, *S. mendax*, *S. inextricata*, and *S. brevis*.

Acknowledgments are gratefully made to Dr. Aldrich (U.S. National Museum), Major E. Austen (British Museum), Messrs. W. W. Froggatt (Government Entomologist, Sydney), H. Tryon (Government Entomologist, Brisbane), and G. F. Hill (Tropical Institute, Townsville, N.Q.), as well as Dr. T. L. and Miss M. J. Bancroft (Eidsvold, Q.), for assistance in regard to material; also Messrs. H. A. Longman, Director of the Queensland Museum, and W. A. Rainbow and A. Musgrave, of the Australian Museum, Sydney, for assistance in regard to literature.

Types, both holotypes and allotypes, will be deposited in the Queensland Museum, Brisbane. Paratypes will, if sufficient be available, be distributed to other museums such as the Australian Museum, Sydney, British Museum, and U.S. National Museum.

Although twenty-one species are described in this paper, all but one (*Helicobia australis*) fall within the limits of the genus *Sarcophaga* as ordinarily accepted. One species, *S.* (*Parasarcophaga*) *omega*, probably represents a new generic type but we have contented ourselves with the erection of a subgenus. Of the remaining nineteen species, the first four described—*S. impatiens*, *S. tryoni*, *S. alpha*, and *S. beta*—are very large flies with bright golden colouration on the head and thorax. The females, as far as known, possess scutellar apical bristles. Probably *S. gamma* belongs to this group but it is more greyish in general appearance. *S. delta* constitutes a group by itself; *S. irrequieta* and *S. eta* another small group of medium-sized greyish flies; *S. misera* and *S. dux* a fourth group. All the others, excepting perhaps *S. bancrofti*, are very similar in size and general colouration and constitute an *aurifrons* group.

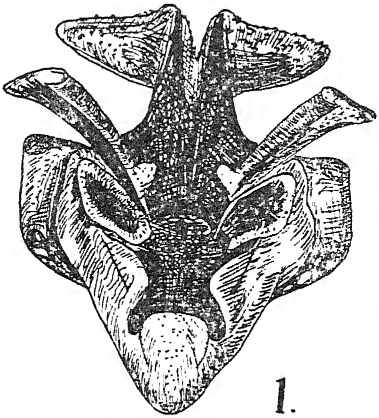
We have not attempted to describe any species of which only the female is represented in our collection.

1. **Helicobia australis** n. sp. (Fig. 24).

In general appearance a small rather slender grey fly, 5 mm. in length and only about 1·2 mm. in breadth.

MALE.—*Head.*—Front fairly prominent; at its narrowest about half the width of eye. Eyes red-brown. Parafrontals, cheeks, and back of head silvery, ferruginous in certain lights. Frontal stripe very dark chocolate, a little wider than parafrontals; mesofacial plates a pale fawn colour. First antennal joint inconspicuous; second large, very dark brown and with a silvery bloom; third less than twice the length of second, silvery. A row of eight frontals beside frontal stripe. Proboscis dark brown externally, much paler on internal (anterior) part; palps black; vibrissa inserted close to oral margin; four facials and three peristomials present. Verticals large, lateral verticals absent. Two rows of black bristles behind eyes, upper row the more complete. Silvery hairs clothe the back of the head, becoming longer but more sparse below; cheeks with black bristles.

Thorax as wide as head, and of a silvery grey colour. The usual three longitudinal lines are present, but are rather irregular and all extend on to scutellum, where the lateral ones are only faintly indicated. Thorax deep grey laterally and ventrally. Anterior spiracle very small, clothed with brown hairs.



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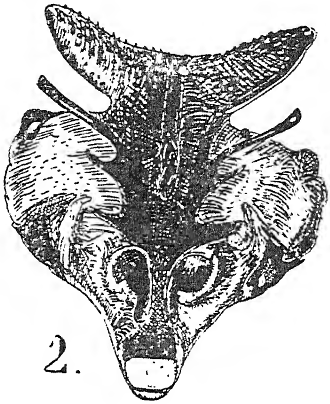

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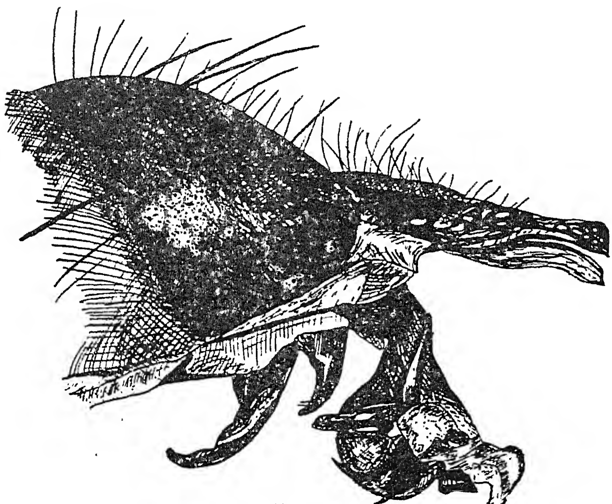


O.W.T.

3.

The last two pairs of anterior acrostichals feebly developed; prescutellar acrostichals moderately strong. Apical scutellars present. Dorsocentrals remarkably well developed; the last two pairs as usual much the largest, the more anterior ones considerably larger than the prescutellar acrostichals. Two intra-alars present; three humerals; two post-humerals, of which the anterior is the larger.

Wings.—In the wing the first longitudinal vein is hairy, thus placing the species in the genus *Helicobia*.

Legs black; first femur not hairy, tibia shorter than tarsus; second and third legs not hairy, second femur without "comb," tarsus longer than tibia; third tibia about as long as tarsus.

Abdomen about as long as thorax, oval; covered with short reclinate bristles above, slightly hairy below; provided postero-ventrally with a few rather long bristles. First segment of hypopygium greyish; second segment very dark shiny brown, hairy, tipped dorsally with light brown. Forceps relatively very large, shiny black, sharply pointed, and exceedingly hairy. Accessory plate somewhat semicircular, hairy. Penis fairly heavily chitinised, bearing posteriorly two long, prominent, ventrally directed processes, as figured (Fig. 24).

Described from two males, bred from decaying meat in Brisbane. *H. australis* is the first representative of the genus to be recorded from Australasia.

2. **Sarcophaga impatiens** Walker 1849 (Figs. 18, 19).

In general appearance a large golden and black fly, the male measuring about 14 mm.; the female somewhat shorter, about 12 mm. long, and much more thick-set.

MALE.—*Head*.—A little narrower than widest part of thorax. Front not very prominent; about three-fifths the width of eyes. Frontal stripe very dark chocolate brown. Mesofacial plates a rich golden colour, borders tinged with black. Parafrontals golden, with dark reflections; cheeks bright golden. Eyes red-brown. Proboscis black and brown, with golden hairs; palps black. Back of head golden, with a single row of short black bristles behind eyes. Hairs below these golden, becoming very long and bright golden on cheeks.

First antennal joint very small; second large and very dark brown, third over thrice the length of second, dark

ferruginous. The second joint bears a prominent bristle. A row of thirteen frontal bristles present. Vibrissæ inserted well above oral margin. Seven facial and five long peristomial bristles present. Lateral verticals inconspicuous.

Thorax golden, with the usual three longitudinal stripes, the middle one alone extending on to scutellum. Sides and ventral surface of thorax golden. Anterior acrostichals present, but very feebly developed. Of the posterior acrostichals only the prescutellar represented; these are moderately strong. Row of dorsocentrals complete; last in row very large. Scutellar apicals present. Anterior intra-alar bristle about as large as prescutellar acrostichal. Humeral bristle large but not extending beyond pronotum. Anterior spiracle dark chocolate coloured, protected by a heavy growth of short golden hairs.

Legs black and grey. First femur tinged with gold; hairy. Second femur hairy, but not heavily so; last tibia hairy. Pulvilli dark brown, fringed with silvery hairs.

Abdomen in male a little longer than thorax, conical; silvery with the usual black and silvery markings, and frequently tinged with gold. Median dorsal black stripe not extending on to last segment. Abdomen hairy beneath. First segment of hypopygium brown, anterior portion almost greyish; second, dark shining brown, almost black, the whole provided with long curly black hairs. Forceps angular and fairly sharp-pointed, the upper half provided with a number of short anteriorly directed bristles, and with long black hairs. Accessory plates dark brown, hairy. Claspers dark brown, almost black; the anterior pair especially strong, due to a great thickening of the lower two-thirds. First joint of penis dark brown; second dark brown, black in parts, bordered with white antero-ventrally, and provided with hooks and chitinous processes, as figured (Fig. 19).

FEMALE.—This differs from the male in the following important characters:—Front slightly more prominent than in male; about five-sixths the width of eyes. Eleven frontal bristles beside the frontal stripe, and three beside eye; these latter extremely large, even more so than in *S. tryoni*; practically only in this respect can the two females be distinguished. Lateral verticals very large. Scutellar apical bristles present, but small and fairly close together. First femur clothed with short hairs ventrally; longitudinal row of bristles very well

developed. Second femur hairless; a "comb" not differentiated. Neither last femur nor tibia hairy. Abdomen oval, shorter and broader than thorax.

Bred from bad meat. This species is very common around Brisbane, especially during early autumn.

A female was kindly identified for us by Mr. E. E. Austen of the British Museum, by comparison with Walker's type (a female) in that collection, described from New Holland. A comparison of our bred females with this form allowed us to determine the hitherto undescribed male. Walker's type is labelled as having come from Sydney. Others in the British Museum have been collected in Tasmania, South Queensland, North Queensland (Stannary Hills, Coll. Dr. Bancroft), and New Hebrides; all determined by Mr. Austen.

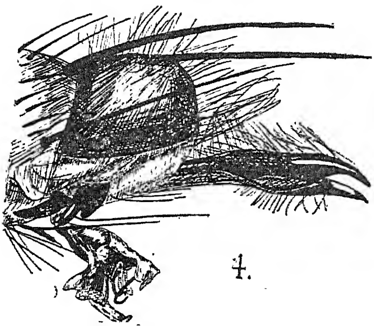
3. **Sarcophaga tryoni** n. sp. (Figs. 9, 10).

Syn.: *S. frontalis* (in part) of Australian authors.

In general appearance bright gold and black. A large *Sarcophaga*, the males measuring about 17 mm. in length, though some may be as small as 11 mm. Female considerably shorter, measuring about 12 or 13 mm.

MALE.—*Head.*—Parafrontals bright gold, with dark reflections. Back of head and cheeks bright gold. Width of front about half that of eyes. Frontal stripe black, about as wide as parafrontals. Mesofacial plate very pale golden, borders tinged with black. First antennal joint very small, dark brown; second much larger, almost black; third joint nearly four times the length of second, ferruginous. A row of eleven frontal bristles present. Verticals large, lateral verticals very small. Epistome prominent, tinged with pink; proboscis black, with golden hairs. Vibrissæ large. About seven small facial bristles present; twelve peristomials. One row of black bristles behind eyes; back of head provided with short golden hairs, forming a beard-like growth on cheeks.

Thorax varying from bright gold to almost ashy colour, and with the usual three black longitudinal stripes, the middle one alone extending on to scutellum. Sides of thorax grey, tinged with gold. Anterior spiracle with a strong growth of short golden and silvery hairs.



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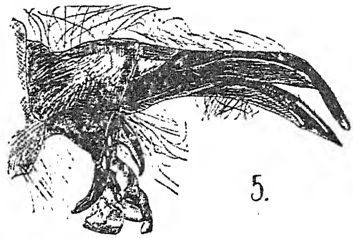

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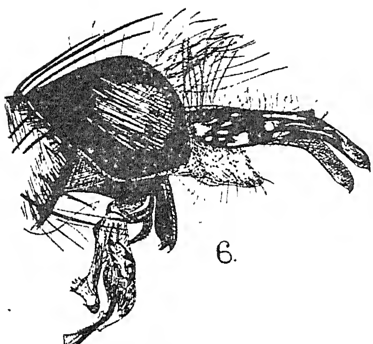

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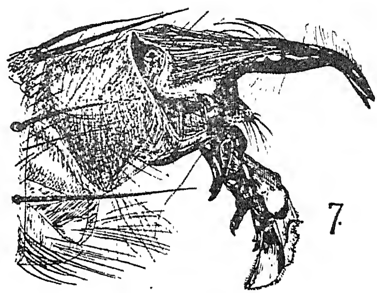

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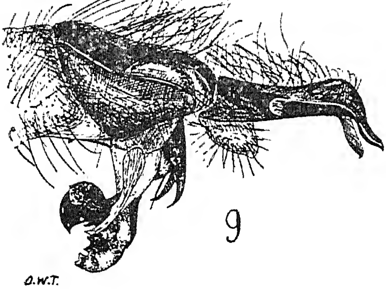

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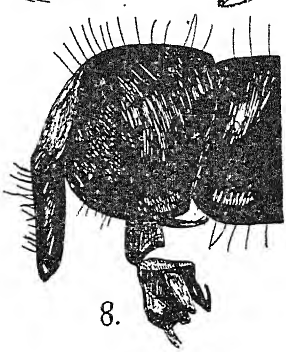

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Anterior acrostichals present, but only posterior pair well developed. Prescutellar acrostichals extend almost to end of scutellum. Dorsocentrals complete; posterior pair extending just beyond scutellum. Three humerals, the lowest reaching about three-quarters of the distance to mesonotum. Anterior intra-alars extremely weak. Scutellar apicals present.

Legs black and grey. Anterior femora tinged with gold. Rows of bristles complete, but not hairy. Second femur with short growth of hairs proximo-ventrally; "comb" developed. Third femur with beard-like growth of hairs; third tibia very hairy. Pulvilli dark brown, with silvery borders.

Abdomen a little broader than thorax. Silvery, with very faint gold reflections; the usual black markings present. The longitudinal black line hardly visible on last segment. Dorsal surface with short black reclinate bristles; ventral side hairy, especially posteriorly. Hypopygium fairly prominent, dark brown, almost black, very hairy. Accessory plate brown, hairy. Forceps dark brown; not smooth; angular; upper part hairy; ventral portion bare; tip not very sharp. Claspers reddish brown. Distal joint of penis divided into anterior and posterior parts, the colour of different portions varying from white to black, according to the degree of chitinisation; the posterior division provided with four short sharp spines (Figs. 9, 10).

FEMALE.—This differs from the male in the following important characters:—It has the shorter, more thick-set appearance typical of females. Colouration identical. Front at narrowest point as wide as eye. Third antennal joint scarcely three times the length of second. Arista slightly more plumose than in male. Frontal stripe a little narrower than parafrontals. Ten bristles in inner frontal row; three very large ones comprising the outer frontal row; the lowest reaching not quite to the base of the antenna. Lateral verticals absent. Thoracic chætotaxy as in male. Scutellar apicals present, but a little closer together than in male, and situated, not lateral to, but behind, the scutellar extension of the median longitudinal black stripe. Anterior femur very faintly hairy. Second femur not hairy, no "comb" developed. Third femur and tibia without hair. Abdomen a little shorter than thorax; oval. Longitudinal black stripe definite on last segment.

Bred from bad meat. This species, with which we have much pleasure in associating the name of Mr. Henry Tryon,

the veteran Queensland Entomologist, is common around Brisbane, especially in March.

S. tryoni is without doubt one of the several species formerly included by Australian entomologists under the name of *S. frontalis*.

4. **Sarcophaga alpha** n. sp. (Fig. 21).

In general appearance a large brilliant gold-and-black insect, the male measuring about 15 mm. in length.

MALE.—*Head.*—Parafrontals bright gold, with dark reflections. Cheeks and back of head bright gold. Frontal stripe almost black; a little wider than the parafrontals. Front rather projecting and about three-quarters the width of the eyes. Eyes reddish brown. First antennal joint small; second much larger, black; third about three times the length of second, ferruginous, and with a silvery bloom. Arista about half as long again as antenna, very strongly plumose. Mesofacial plates golden, bordered with black. Proboscis black, with pale-gold hairs; palps black. Epistome prominent.

A row of eleven frontal bristles present; vibrissæ inserted somewhat above the oral margin. Five large and numerous smaller facial bristles; thirteen large epistomials. Verticals very large; lateral verticals medium-sized. A single row of black bristles behind eyes. Back of head provided with golden hairs, which become very long on cheeks.

Thorax golden, with three longitudinal black lines, of which the middle one extends on to the scutellum. Sides of thorax golden, with black markings; ventral side grey. Anterior spiracle black, with a few golden hairs.

Anterior acrostichals present, but small. Of the posterior acrostichals only the prescutellar occur. Dorsocentrals present; last two larger; last very large. First humeral bristle as large as first dorsocentral; last humeral not extending to the mesonotum. Scutellar apicals present.

Legs black, tinged with grey. Femur of first leg tinged with gold; dorsal and ventral longitudinal rows of bristles very well developed; very hairy. Second femur hairy on the proximal ventral side, but not markedly so; "comb" differentiated. Third femur very hairy. Third tibia very hairy; second hairy on ventral distal portion; first not hairy. Third tarsus a little longer than tibia. Pulvilli very dark brown, borders silvery.

Abdomen about as broad as thorax but considerably longer, measuring 8 mm. ; pale golden, with the usual black markings. The dorsal black line complete. Dorsal surface covered with very short black reclinate bristles. Ventral surface slightly hairy, especially on last segment. Hypopygium large, shiny black, hairy. Forceps shiny black, and very definitely angular ; lower arm of the angle bare, upper arm hairy ; at the angle a number of short hairs and short blunt bristles. Accessory plate very dark brown, hairy. The posterior clasper is remarkable, in that it is provided with three prongs.

The penis closely resembles that of *S. crinita* from the Philippines, described and figured by Parker (1917). The upper joint is very dark brown, in places shining black. The lower is heavily chitinised on its proximal side, and from this are given off two anteriorly projecting curved shiny black hooks, supported dorsally and ventrally by a pair of large, but not heavily chitinised, "sheaths" (Fig. 21).

Described from two males caught around bad meat in Brisbane.

5. **Sarcophaga beta** n. sp. (Fig. 6).

In general appearance a large golden insect ; smaller specimens not unlike *S. aurifrons* Mcq. Length 11 to 14 mm.

MALE.—*Head.*—Front slightly prominent, about half the width of eyes. Eyes dark red-brown, rather flat in front. Frontal stripe nearly black, as wide as parafrontals. Parafrontals, genæ, and occiput bright golden. Mesofacial plates golden, borders tinged with silver. First antennal joint inconspicuous, second large and very dark ferruginous, third less than thrice the length of second and of a deep fawny colour. Epistome not very conspicuous. Vibrissæ large, inserted well above oral margin ; seven facials present, eight peristomials ; thirteen pairs of frontals beside frontal stripe ; verticals fairly large, lateral verticals absent. A single row of black bristles behind eyes ; occiput covered with weak golden hairs, which form a bright-gold beard-like growth on the posterior parts of the genæ ; anterior part of genæ with shorter bright-golden hairs. Proboscis typical.

Thorax golden, with the usual black stripe, the median one alone extending on to scutellum ; sides golden ; under

side greyish. Three humerals present; the last two pairs of anterior acrostichals feebly represented. Of the posterior set, only the prescutellars are developed. Dorsocentral row complete; two intra-alars present. Anterior spiracle with light-brown hair.

Legs black and grey. First femur hairy; the longitudinal rows of bristles very completely developed; tibia longer than tarsus. Second femur hairy proximo-ventrally; a "comb" differentiated; tibia extremely hairy. Third femur very hairy; tibia moderately so.

Abdomen with usual black and white markings, the median black line extending faintly on to last segment. Covered above with short reclinate bristles, below rather hairy.

First segment of hypopygium brown, slightly pollinose; second shiny, almost black, hairy. Forceps shiny black, sculptured externally; approximated for about two-fifths their length, sharply pointed, angular in lateral view, the upper arm only being hairy. Accessory plates somewhat oval in shape, dark brown, with long hairs. Claspers very dark brown; posterior clasper very broad; the anterior clasper with two strong processes. The anterior part of the membrane surrounding the base of the penis also develops a short, blunt, yellowish process. Distal joint of penis fairly heavily chitinised. It is of the *S. crinita* type, as figured by Parker (1917), and consists of a posterior sheath, which lodges the base of a pair of strong processes, serrated anteriorly, and tipped with white. Anterior to the sheath is a movable hook-like structure, bearing in front a strongly serrated membrane, greyish in colour. The whole copulatory organ very closely resembles that of *S. delta*.

FEMALE.—This differs from the male in the following characters:—Eyes rather flat in front, giving the front a rather prominent appearance. Front about three-fifths the eye-width. A row of nine frontals beside frontal stripe, and three larger ones immediately beside eyes. Lateral verticals present and well developed. Thoracic chætotaxy as in male, except that apical scutellars are rather weaker. First femur moderately hairy, tibia slightly longer than tarsus. Second and third femora and tibiæ hairless. No "comb" on second femur.

Described from two males and two females bred from decaying meat in Brisbane, February 1921.

6. **Sarcophaga gamma** n. sp. (Fig. 15).

In general appearance a medium-sized fly, about 13 mm. in length, and of a faintly golden greyish colour.

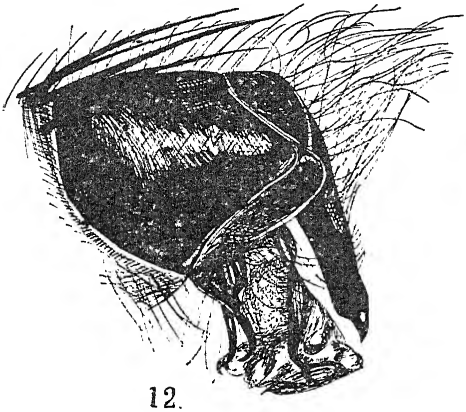
MALE.—*Head.*—Front not very prominent; about three-quarters the width of the eye. Frontal stripe very dark chocolate brown, nearly black; almost twice the width of the parafrontals at their narrowest point. Parafrontals, genæ, and occiput bright golden. First antennal segment more conspicuous than usual; second large, very dark brown; third a dark fawn colour and about twice the length of second. Frontal field pale golden, borders dark; epistome not prominent. Proboscis and palps as usual. Eyes dark red-brown. Nine frontals. Verticals moderately developed; lateral verticals small. Vibrissæ inserted well above the oral margin. Four facials and twelve peristomials present. A single row of short black bristles behind eyes; hairs below this short and golden, becoming longer below on the genæ; those on anterior part of genæ shorter.

Thorax grey, tinged with gold. The usual three black lines present; the median extending on to scutellum where the laterals are only indistinctly represented. Under side grey; sides grey, tinged with gold. Of the acrostichals only the prescutellar are present, and these are but very faintly developed. Dorsocentral row complete. Apical scutellars present; anterior intra-alars exceedingly weak. Anterior spiracle with pale-golden hairs.

Legs grey and black. First femur with just a tinge of gold, slightly hairy; longitudinal rows of bristles very complete. Second femur hairy proximo-ventrally, with a well-defined "comb" distally; tibia longer than tarsus. Third femur hairy; tibia heavily clad with short hairs.

Abdomen covered dorsally with short reclinate bristles; hairy beneath. Conical in general shape, and a little longer than thorax. With the usual black and white markings; the dorsal black line extending on to last segment.

First segment of hypopygium silvery; second half the length of first, nearly black and shiny, hairy. Accessory plates triangular, brown, hairy. Forceps very well developed, shiny black, approximated for over half their length; tips bare, remainder very hairy. Claspers simple; dark shining black. First joint of penis very dark brown; second dark



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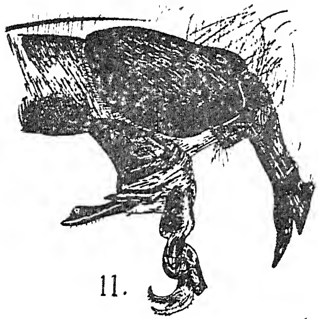

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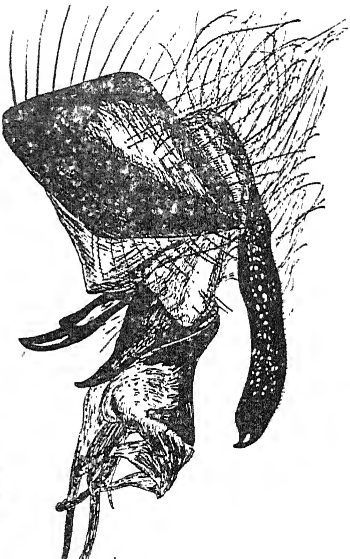

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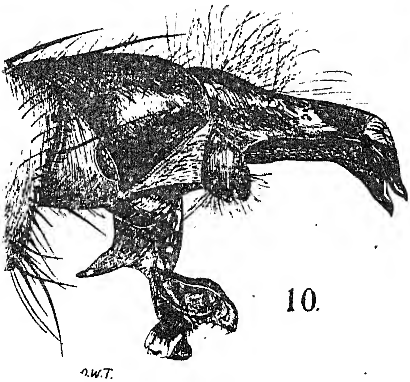

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brown and shiny black, in places white. The distal portion is divided into two parts, of curious appearance, as figured (Fig. 15).

Described from two males captured around decaying meat in Brisbane, April 1921.

7. **Sarcophaga delta** n. sp. (Fig. 13).

In general appearance a large grey fly, about 15 mm. in length.

MALE.—*Head.*—Front slightly prominent, about two-fifths the width of eye. Frontal stripe very dark chocolate, rather narrower than parafrontals, which are pale golden, and rather more heavily pollinose than usual; genæ rather brighter golden; occiput silvery with pale-golden tint. Mesofacial plates silvery, with somewhat darker borders; ptilinal suture fairly distinct throughout life. First antennal joint rather more prominent than usual; second large and nearly black; third a fawn colour, and about thrice the length of the second. A row of ten frontals beside frontal stripe; eight facials, and fourteen peristomials, some of the latter exceedingly large. Verticals present; lateral verticals present, but very weak. A single row of black bristles behind eyes. Back of head heavily clad with pale-golden hairs, developing into a beard-like growth postero-ventrally, and much shorter on the anterior part of the genæ. Proboscis as usual, palps black.

Thorax.—This is of a deep grey, with the usual black longitudinal marks, the middle one alone extending on to scutellum. Lateral and vertical parts grey. Anterior spiracle heavily coated with short brown hairs. Shoulder armed with moderately long black bristles. Anterior acrostichals all present, though very weak, posterior pair rather stronger than the others. Of the posterior row, only the prescutellars are present; these are very strongly developed. Apical scutellars very long. Dorsocentral row complete. There is an indication of a third intra-alar.

Legs black and grey. First femur slightly hairy, tibia longer than tarsus. Second femur slightly hairy proximo-ventrally, a "comb" differentiated; tibia hairy. Third tibia hairy; of a dark-brown colour.

Abdomen a deep grey with the median longitudinal deep-brown line feebly developed, and not distinctly visible on

last segment. Segments very faintly tinged with deep brown. Covered dorsally with short, black, reclinate bristles; slightly hairy ventrally, on all except last segment, which is very hairy.

First segment of hypopygium pale brown anteriorly, nearly black posteriorly, hairy; second segment shiny black and only very lightly hairy. Forceps very long, deep brown above, black below and slightly angular; not very sharply pointed. "Angle" armed with short black bristles; claspers dark shiny brown; the anterior clasper with two prongs. The penis shows a remarkable resemblance to that of *Sarcophaga beta*, which is in every other respect a quite distinct fly. The large anterior "hook" is present, but rather more slender; the pair of ventrally directed prongs also present, but not serrated anteriorly.

Described from one male captured by Mr. H. Jarvis on flowers in Brisbane, and kindly donated by Mr. Tryon.

8. **Sarcophaga irrequieta** Walker 1849 (Figs. 1, 2, 3).

Syns.: *S. ochripalpis* Thomson 1868.
S. frontalis Johnston and Bancroft 1920.

In general appearance an ashy coloured fly, about 11 to 12 mm. long, though at times much smaller (7 mm.).

MALE.—*Head.*—Parafrontals silvery with dark reflections, and very faintly tinged with gold. Front at narrowest part about one-fifth the width of head. Frontal stripe almost black, one and a-half times the width of parafrontals. Mesofacials faintly golden in the middle, more silvery at sides. First antennal joint small; second large and black; third over thrice the length of second, ferruginous, with faint silvery bloom. Arista plumose for over half its length and considerably longer than the three antennal joints combined. Eyes dark red-brown, the anterior facets larger than the posterior. Back of head dark grey, faintly tinged with gold immediately behind the eyes; cheeks lighter grey, gradually merging into the colour of the parafrontals. Proboscis dark brown, almost black, clothed with long golden hairs. Palps varying from ferruginous to almost black. Vibrissæ long, inserted close to the oral margin. About ten moderately large facial bristles present. About ten rather long epistomials. Cheeks covered with short black bristles. A single row of twelve frontal

bristles. Lateral verticals very small. Three rows of black bristles behind eyes. Hairs, behind these, short and golden. Genæ provided with very long silvery hairs.

Thorax grey, faintly tinged with gold, especially around sides; frequently the thorax is quite grey. Three fairly regular longitudinal stripes present, of which the middle one alone extends on to the scutellum. Anterior spiracles dark chocolate in colour, covered with short silvery hairs. Ventral side of thorax greyish, provided with short black bristles; median ventral plates pink. Three humeral bristles present, of which the lowest two are rather large, and much larger than the first. Of the acrostichals, only the prescutellar pair is present. Anterior dorsocentrals rather weak. First posterior dorsocentral very weak; second a little larger, third much larger, fourth extending well beyond scutellum. First intra-alar very small, second very large. Apical scutellar bristles present.

Legs.—Coxæ dark grey, well armed with bristles. Femora black and grey, often faintly tinged with gold. First femur slightly hairy on its proximal ventral side; second femur more hairy, median ventral bristles differentiated into a "comb"; third femur hairy on median ventral side. Pulvilli dark brown, fringed with very minute silvery hairs.

Abdomen greyish gold in appearance, with the ordinary black markings. Upper surface covered with short reclinate bristles; ventral side hairy.

Hypopygium shining black, hairy, and not visible from above. Forceps shiny black, sculptured, dark brown on inner surface. Accessory plates brown, hairy, but not markedly so. Claspers heavily chitinised, shiny black.

The first joint of the penis is dark brown; the second forms a highly chitinised structure almost uniformly black. Viewed ventrally (Figs. 1, 2) it is triangular in shape, the apex of triangle pointing backwards. The organ is provided with two pairs of downwardly, outwardly, and ventrally projecting pale-brown chitinous processes, and with a pair of very heavily chitinised triangular, somewhat rounded masses, highly serrated on their anterior surface, giving the whole organ a remarkable appearance in lateral view (Fig. 3). In ventral view there can be seen two pale-yellow inwardly projecting chitinous pieces given off from the more anterior part of the triangle.

FEMALE.—This differs from the male in the following characters :—Front less than one-third width of head. A row of eleven frontals beside the frontal stripe, three others immediately beside the eye, and converging above on to the first row. Lateral verticals nearly as large as verticals. Scutellar apicals absent. Legs not hairy. Anterior femur with very complete ventral row of bristles ; only slightly hairy. In the second femur, the median ventral row is poorly developed ; no "comb" is differentiated. Third femur not hairy. Pulvilli in the form of short tubes. Abdomen a little longer than thorax ; oval. Sometimes grey, at other times distinctly golden. Ordinary black markings present. A black stripe, sometimes very distinct, runs down the middle of the abdomen. Dorsal surface with small reclinate bristles ; ventral surface hairy, especially posteriorly.

This species appears to be identical with *S. ochripalpis* Thomson 1868, originally described from Sydney. We have suggested that *S. irrequieta* may perhaps be synonymous with *S. musca* described many years earlier by Robineau-Desvoidy (1830). Walker's type specimen, a female, came from the Houtman's Abrolhos, off the coast of West Australia. Our material was bred from decaying meat in Brisbane.

9. **Sarcophaga eta** n. sp. (Fig. 14).

In general appearance a medium-sized fly, about 11 mm. in length and closely resembling *S. irrequieta* Walker.

MALE.—*Head*.—Front a little prominent, about half the width of eyes. Frontal stripe very dark brown, a little wider than parafrontals. The latter silvery, tinged faintly with gold ; cheeks a little paler. Rear of head faintly golden, almost silvery. Mesofacial plates silvery, tinged with gold ; borders blackish. Eyes red-brown. First antennal joint longer than usual, easily visible ; second more slender and longer than usual, nearly black ; third joint less than twice length of second. Arista plumose but not very strongly so. Proboscis dark brown ; palps very dark ferruginous, almost black. The ptilinal suture remains very distinct throughout life. A row of nine frontals beside the frontal stripe. Vibrissæ inserted just above oral margin. Five rather small facials present ; peristomials eight in number, not very large. Cheeks provided with small black bristles. Two rows of black bristles behind eyes, the upper the more complete. Back of head covered

with short silvery hairs, which become longer on cheeks, but do not develop into a strong beard-like growth. Vertical bristle large ; lateral vertical very small.

Thorax grey, with three longitudinal black lines, of which the middle one alone extends on to scutellum. Tip of scutellum faintly golden. Lateral and vertical parts of thorax grey. Of the acrostichals, only the prescutellar pair is present. Dorso-centrals complete, the last pair just extending beyond scutellum. Three well-developed humerals present. Apical scutellar bristle present. Anterior spiracle dark chocolate colour, with brown hairs.

Legs black and grey. First femur slightly hairy proximally ; ventral longitudinal row of bristles very complete ; first tarsus not longer than tibia. Second femur slightly hairy on proximal ventral half, "comb" developed ; second tibia hairy ; tarsus a little longer than tibia. Third tibia hairy ; tarsus nearly as long as tibia. Pulvilli brown, fringed with delicate silver hairs.

Abdomen a little longer than thorax, with the usual black and silvery markings, the middle black line not definite on last segment. Short black reclinate bristles above, hairy beneath. Hypopygium almost black, shiny, very hairy. Forceps fairly straight, provided with a heavy growth of short hairs on its upper half. Posterior connecting membrane very feebly developed, though the forceps are approximated for about two-thirds their length. Accessory plates triangular, very dark brown, hairy ; claspers shiny black. The penis is probably to be regarded as of a much modified *tuberosa* type ; the posterior ventral spine being present and the anteriorly projecting chitinous bars represented by a pair of somewhat slender, curved, non-bifurcated pieces of chitin. Foliaceous chitin masses resembling those of *S. misera* var. *dux* are present, but are produced ventrally each into a long brown chitinous process.

FEMALE.—This differs from the male in the following important characters :—Front slightly wider than eyes ; an inner row of nine frontal bristles present, an outer of three, of which the lowest is very large. Scutellum more abbreviated than in male. Thoracic chætotaxy as in male, except that last pair of posterior dorsocentrals extend well beyond scutellum. Scutellar apicals absent.

Legs.—First femur not hairy; second and third femora and tibiæ devoid of hair, no "comb" on second femur. Abdomen shorter than in male, oval; the middle black line extending on to last segment.

Described from specimens bred by Mr. Henry Tryon from fish, in Brisbane. We have also collected one male attracted to bad meat in Brisbane.

10. Sarcophaga misera Walker 1849 (Fig. 22).

Syns.: *S. frontalis* Thomson 1868.
S. frontalis (in part) Froggatt 1907.
S. frontalis Tryon 1917.
S. misera Cleland 1912, 1913.
S. misera Johnston and Bancroft 1920 (*a* and *b*).

A moderate-sized fly, approximately 12 mm. in length, though some specimens may be as small as 7 mm.

MALE.—*Head.*—Parafrontals pale golden, somewhat darkly tinged. Breadth of front at narrowest point about one-fifth width of head; cheek height one third that of eye. Eyes dark red-brown. Frontal stripe dark brown, almost black. First antennal segment inconspicuous; second large and black; third black, tinged with grey, and about twice the length of the second. Arista plumose for over half its length. One row of black chætæ behind eyes. Bristles below these irregular, dark, merging into longer golden hairs on genæ. Anterior part of cheek provided with long black chætæ. First segment of proboscis black, tinged with silver and pink; second segment shiny black; hairs of proboscis dark golden. Palps varying from brown to almost black. Lateral verticals absent. Vibrissæ inserted just above the oral margin. A single row of ten frontal bristles present, reaching down below the insertion of antenna.

Thorax greyish, tinged with gold; sometimes rather bright gold in appearance. Three dark irregular longitudinal stripes, extending on to the scutellum. Thorax at wing insertion pinkish. Bristles on thorax rather short, reclinate. Three humeral bristles present, of which the lowest is the longest. Anterior acrostichals absent. Three anterior dorso-centrals present, but very short. Outer presutural very large.

inner very weak. Four posterior dorsocentrals, first short, second a little longer, third much longer, fourth extending well beyond scutellum. Scutellar apical present. Three (at times five) sternopleurals. Ventral side of thorax silvery, sometimes tinged strongly with gold. Clothed with short black bristles, but not thickly.

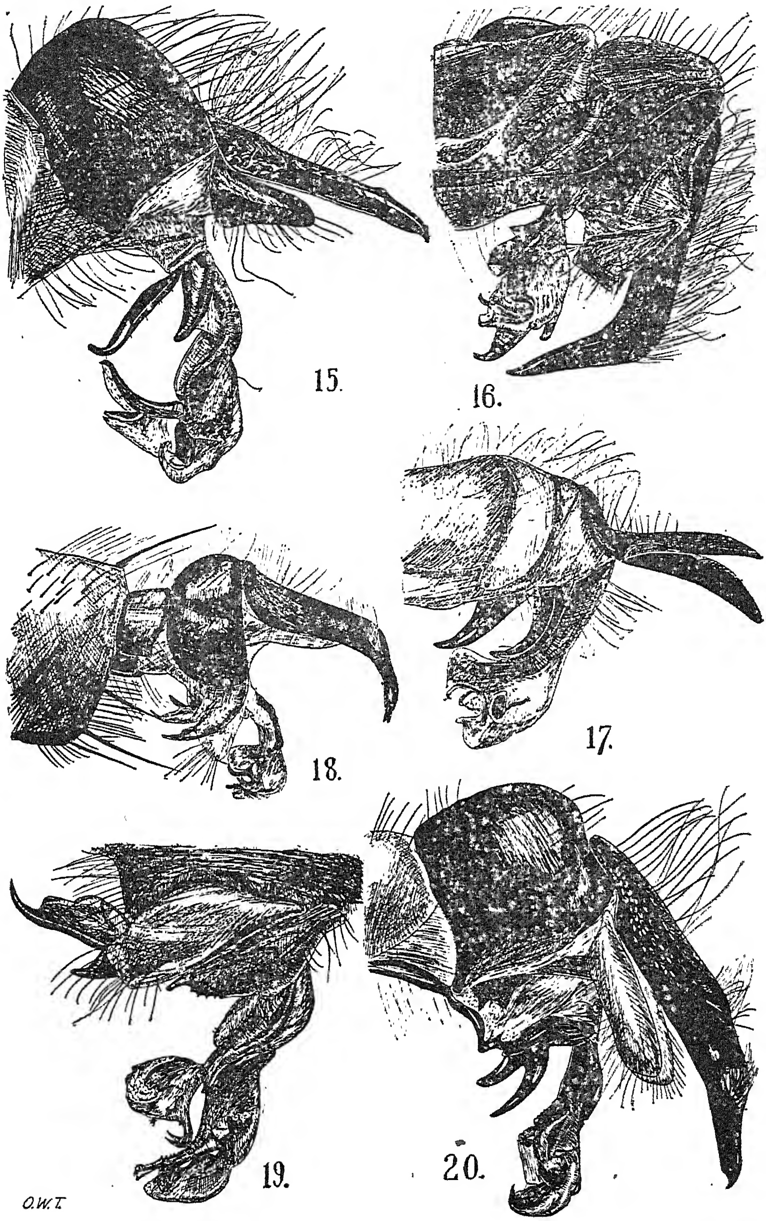
Legs black, tinged with grey. Second and third coxæ tinged with silver and pink. Coxæ strongly armed with reclinate bristles. Proximal end of first femur with a small number of rather short hairs ; second femur provided on its lower proximal half with a beard-like growth of very long hairs, while extending from the hairs to the top of the femur on its posterior part is a row of short stout bristles, about ten in number, forming a "comb." Tarsi not shorter than tibiæ ; pulvilli large, black, fringed with minute white hairs.

Abdomen black and silvery, clothed above with short reclinate bristles, beneath with longer hairs. Second segment without marginals ; third with two ; complete row on fourth.

Hypopygium black, not very prominent. Forceps black. Hypopygium and upper part of forceps provided with long curly hairs, which gradually shorten on the forceps ; the tip of the latter bare. Prongs of forceps connected for varying distances by membrane. Copulatory organs of *tuberosa* type. Claspers dark brown. Accessory plates almost black, hairy. First joint of penis black, heavily chitinised ; second joint somewhat triangular, the posterior end produced into a short sharp point, and bearing two large forwardly projecting prongs slightly bifurcated anteriorly ; the whole dark brown, except in the most heavily chitinised parts, which are black. Between the anteriorly projecting chitinous pieces is a pair of pale-yellow serrated chitinous processes. The anterior portion of the penis is whitish.

FEMALE.—The female is usually a little larger than the male, especially, of course, in the abdominal region.

Front about one-third the width of head. Frontal bristles in two rows ; one beside the eye, consisting of four bristles ; the other situated along the frontal stripe and composed of ten bristles. Scutellar apicals absent. Anterior femur slightly hairy, others not so ; the ventral row of bristles of the second femur complete, i.e. no "comb" is differentiated. Third coxa bears a short apical bristle.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Abdomen oval; genital segments are not visible from above. First ventral-plate short but wide, second longer but narrower and bearing ten bristles, third still narrower with four bristles, fourth very narrow, fifth and sixth very narrow and fused.

Our specimens were bred from bad meat in Brisbane and horsedung in Eidsvold.

This species was first described by Walker (1849, p. 829), the type in the British Museum being a female from "New Holland." That institution also has specimens sent by Dr. Bancroft from the Burnett River. Mr. E. E. Austen, of the British Museum, has identified for us, by comparison with Walker's type, some females which are co-specific with other females common in Brisbane, while males have been obtained by breeding.

Mr. W. W. Froggatt, of Sydney, has kindly allowed us to examine a specimen collected at North Pine, near Brisbane, originally determined for him by Coquillet as *S. frontalis*,[1] and referred to by him under this name (Froggatt, 1907, p. 315). It has been found specifically identical with *S. misera*. Johnston and Bancroft (1920, p. 75) have already referred to the presence of this species (Burnett River and Brisbane), while Cleland (1912, p. 150; 1913, p. 567) reported its occurrence in Sydney and Adelaide. Walker in his original description mentioned its presence in West Australia. Mr. Tryon (1917, p. 53) has referred to *S. frontalis* as one of the Queensland sheep maggot-flies. It seems to occur, then, over the whole of Australia.

11. S. misera Walker var. **dux** Thomson 1868 (Fig. 23).

Syns.: *S. dux* Thomson 1868.
S. frontalis (in part) Froggatt 1907.
S. subtuberosa Parker 1917.

Among the male *Sarcophagas* captured around carrion in Brisbane are a few which are in every way identical with the males of *S. misera* except for small differences in the structure of the penis. In these forms the anteriorly projecting bifurcated chitinous bars at the termination of the organ are considerably shorter and stouter, whereas the chitinous mass above these is much weaker, and even foliaceous in appearance

[1] Thomson's specific name was already preoccupied, *S. frontalis* having been given to a fly from Amboina by Doleschall in 1858.

(Fig. 23). One of these males was submitted to Dr. J. M. Aldrich of the United States National Museum, who determined it as *S. dux* Thomson. These males cannot be distinguished from *S. subtuberosa*, described from the Philippines and Guam by Parker (1917). In a note to Dr. E. W. Ferguson of the Health Department, Sydney, Dr. Parker referred to the latter species as being synonymous with *S. dux* Thomson. A female specimen of *S. dux* from Honolulu, kindly lent us by Mr. Henry Tryon, is indistinguishable from females determined by E. E. Austen as *S. misera*. These forms agree so closely with Walker's species that the differences are sufficiently recognised by placing the flies under the name *S. misera* var. *dux*.

The distribution of this variety is very wide. Thomson described his material from Honolulu, where its presence has also been referred to by Grimshaw and by Timberlake (1917). Parker's specimens came from the Philippines and Guam ; ours were captured in Brisbane. This variety is one which has no doubt been included under *S. frontalis* by Australian authors, and is probably common in New South Wales.

12. **Sarcophaga aurifrons** Macquart 1846 (*nec* Doleschall 1858) (Fig. 4).

Syns. : *S. aurifera* Brauer and Bergenstamm.
S. aurifrons Froggatt 1905, 1907, 1915.
S. aurifrons Tryon 1917.
S. aurifrons Johnston and Bancroft 1920.
S. aurifrons Mackinnon 1920.

In general appearance a medium-sized greyish golden fly, about 10 mm. in length.

MALE.—There is considerable variation in the shape of the head. In some specimens the eyes are either flat in front or (sometimes) slightly bent inwards giving the small frons a very prominent appearance. In each form the frons at its narrowest point is about one-third the width of eyes ; while the frontal stripe is wide below, then becoming exceedingly narrow (less than half the width of parafrontals), widening again in the region of the ocelli. In other specimens the eyes are more projecting, the front proportionally less prominent. and the frontal stripe about two-thirds the width of an eye. The two types may occur among forms bred from the same parent. Eyes very dark red-brown. Parafrontals bright

golden, with dark reflections; genæ paler gold provided with black bristles. Occiput bright golden. Mesofacial plates very pale gold, almost silvery, with dark borders.

First antennal segment moderately conspicuous, black; second large, black, with silvery bloom; third less than twice the length of second, ferruginous, with silvery bloom. Vibrissa inserted close to oral margin; four small facial bristles; seven or eight epistomials. A row of nine frontals present. Verticals moderately large, lateral verticals inconspicuous. Three rows of black bristles behind eyes; genæ with short golden hairs posteriorly, longer below, but never forming a beard-like growth.

Thorax greyish gold above, brighter gold on sides, grey beneath. Dorsal surface with the three usual longitudinal stripes of which the middle one alone extends on to scutellum. Anterior spiracle dark chocolate, well provided with yellowish silvery hairs. Of the acrostichals only the prescutellar pair present. The row of dorsocentrals is complete, the posterior pair extending well beyond the scutellum. Anterior intra-alar very weak. Upper humeral very weak. Scutellar apicals small. Halteres brown.

Legs black and grey. First femur very faintly tinged with gold; longitudinal rows of bristles complete; not hairy; tibia a little longer than tarsus. Second femur not hairy; a "comb" of eight bristles differentiated; second tibia hairless, and much longer than tarsus. Third femur very faintly hairy; tibia a little longer than tarsus, hairless.

Abdomen somewhat shorter than thorax, with the usual black and silvery markings, the silvery predominating. The median longitudinal stripe does not extend on to the last segment. Hypopygium not visible from above; very dark shining brown, almost black, and provided with rather short black hairs. Forceps slightly curved, sharply pointed, shiny black, hairy; posterior two-thirds bare. Claspers dark shiny black. The penis is a very complex organ; first joint shiny black; the second very strongly chitinised and provided with several complex white or brown chitin pieces (Fig. 4).

FEMALE.—This closely resembles the male in general appearance and body proportions. Frons a little broader than width of eye. Frontal stripe about the width of parafrontals. Outer row of three frontal bristles well developed. Thoracic

chætotaxy as in male except that the apical scutellars are absent. The second femur does not develop a "comb." Posterior trochanter with apical bristle. Abdomen a little more rounded than in male; the dorsal longitudinal line extends on to last segment.

Our specimens were bred from bad meat in Brisbane in November 1920.

Mr. W. W. Froggatt kindly allowed us to examine a female fly from the Brisbane district, determined for him by Coquillet as *S. aurifrons* Macquart. This female could be identified specifically with others which we have bred (along with the males) from bad meat. As these flies did not differ in any way from the scanty description given by Macquart, we have accepted them as belonging to this species, hoping, by giving an account of the male copulatory organs, to remove the confusion which appears to prevail regarding this fly. Macquart's account could cover several species, and an examination of his type, if in existence, would be necessary to settle which, if any, of the many related forms herein described actually represents his species. Failing that, the above account will stand as valid for the species.

This fly is generally regarded as one of the sheep maggot-flies of N.S.W. and Queensland (Tryon 1917, p. 53). Macquart mentioned as localities "New Holland" and Tasmania. It is not very common about Brisbane. Mr. W. W. Froggatt has given a coloured figure and a short account (1905; 1907; 1915, p. 29, fig. 4). Mackinnon (1920, p. 553) has also published a figure.

In 1858, Doleschall described a different fly from Amboina as *S. aurifrons* n. sp., but as the specific name was already preöccupied his species might be renamed *S. doleschalli*.

13. Sarcophaga froggatti Taylor 1917 (Fig. 12).

Syns.: *S. knabi* Parker 1917.
S. aurifrons (in part) of Australian authors.

General appearance grey and golden. A medium-sized fly, varying from 6 to 11 mm. in length.

Male.—*Head*.—Front a little less than half the width of eyes. Parafrontals bright golden. Mesofacial plates pale golden, borders faintly tinged with brown. Cheeks and genæ

golden. Frontal stripe ferruginous, with a faint silvery brown. First antennal segment short and black; second much larger, black, with a ferruginous tinge, and silvery bloom; third joint about twice the length of the second. Arista dark brown at base, remainder light brown; strongly plumose for over half its length. Eyes reddish brown. Epistome prominent and silvery. A single row of black bristles behind eyes; bristles behind these weak and golden, becoming very long below. Cheeks provided with short golden hairs. A row of nine frontal bristles present. Lateral verticals present, but not very large. Four very weak facial bristles, also eight somewhat larger epistomials.

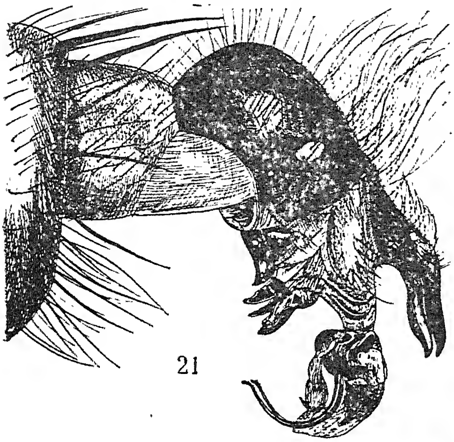
Thorax somewhat ashy coloured above, tinged with gold. Longitudinal stripes irregular, the middle one alone extending on to the scutellum. Ventral side of thorax greyish, with golden areas. Anterior spiracle brown, clothed with golden hairs.

Of the acrostichals only the prescutellar pair present. Anterior dorsocentrals weak, first posterior weak, second weak, third considerably larger, fourth very large. Three humerals present, of which the lowest is very large, extending beyond the pronotum. Scutellar apicals very large. Anterior intra-alar bristle as large as first anterior dorsocentral.

Legs dark grey, tinged with silver. Inner side of coxæ grey, armed with long reclinate bristles, outer side dark, ferruginous. First femur hairy on ventral side, but not markedly so. Second femur a little hairy proximally, mid-ventral row of bristles developed into a "comb." Third femur strongly hairy. Third tibia very hairy. Pulvilli brown.

Abdomen silvery with ordinary dark-grey markings, provided above with short reclinate bristles, below with long hairs. Hypopygium very dark brown, almost black, very hairy. Forceps brown above, black below, hairy, tips bare; connecting membrane poorly developed. Accessory plates dark brown, provided with long thin hairs. Claspers shiny black.

The penis is of the *tuberosa* type; the chitinisation being not markedly heavy, so that the greater part of the organ is brown, not black. It is somewhat triangular in shape, the posterior ventral corner giving off a very short blunt process,



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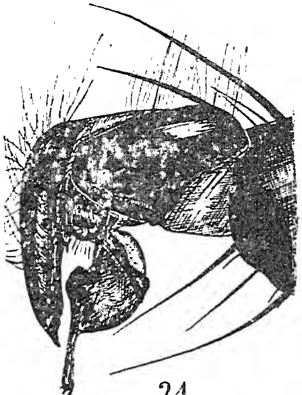

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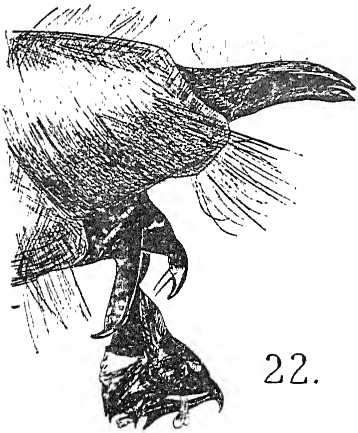

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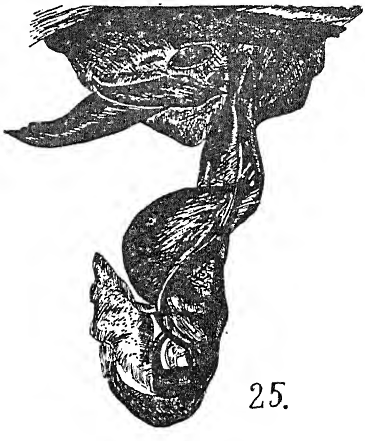

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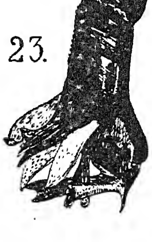

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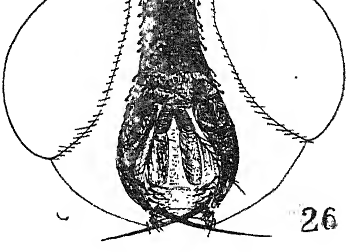

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from which a pair of yellowish "scythe-like" processes run forwards and meet. Immediately above this there is a complicated but rather weak mass of chitinised tissue (Fig. 12).

FEMALE.—The female differs from the male in the following characters :—Front equal to width of eyes. Lateral ventral bristles almost as large as verticals. Eight frontal bristles beside frontal stripe; three others converging upon these beside the eye. Lowest humeral bristle does not extend to mesonotum. Femora not markedly hairy; no "comb" developed on second femur; posterior tibia hairless. Abdomen a little shorter but broader than thorax; oval in shape, and with the usual black and grey markings.

A male of this fly was submitted to Dr. Aldrich, who determined it, by an examination of the male genitalia, as *S. knabi* Parker 1917. Mr. G. F. Hill of the Tropical Institute, Townsville, kindly sent us some specimens which he found to be co-specific with Taylor's type in the Institute Collection. A comparison of the male genitalia of these forms, with the specimen which Dr. Aldrich determined as *S. knabi*, shows the two to be specifically identical, and to agree entirely, also, with *S. knabi* as described by Parker. *S. froggatti* Taylor and *S. knabi* Parker are therefore synonymous, the former having a few months' priority. Townsend (1917, p. 191) created a genus *Glaucosarcophaga* with *S. knabi* as type. If the genus be accepted then the correct name of the type is *G. froggatti*.

This fly has a very wide range. Taylor's material came from Winton (Central Queensland); our own is from Brisbane; Dr. Parker's specimens were collected in the Philippine Islands.

14. Sarcophaga zeta n. sp. (Fig. 20).

General appearance closely resembling *S. aurifrons* Macq. Length 12 mm.

MALE.—*Head.*—Front not very prominent; at its narrowest about two-fifths the eye-width. Frontal stripe very dark brown, almost black, equal in width to the parafrontals. The latter bright gold, with dark reflections; genæ a little paler golden. Eyes dark red-brown. Mesofacial plates bright golden, borders very faintly tinged with black; back of head golden. Epistome prominent, pinkish. First antennal joint

inconspicuous; second much larger, nearly black; third ferruginous, with silvery bloom, and thrice the length of second. A row of fourteen frontal bristles present; seven facials; nine epistomials. Proboscis black, with golden hairs; palps almost black. A single row of black bristles behind eyes; hairs on back of head golden; hairs on genæ pale gold, and moderately long. Verticals present, but not very large; lateral verticals absent.

Thorax pale golden, with three longitudinal black stripes of which the middle one extends as a faint indication on the scutellum. Scutellum distinctly grey. Sides of thorax pale gold and silvery; ventral side grey. Last pair of anterior acrostichals present; prescutellar acrostichals well developed. Dorsocentral row complete, the last two larger than others; three humerals well developed, the lowest not extending to mesonotum. Anterior intra-alar slightly larger than usual. Scutellar apicals well developed.

Legs black and grey. First femur golden on ventral side; longitudinal row of bristles complete; femur moderately hairy. Second femur with a well-developed "comb," only very slightly hairy; second tibia not hairy. Third femur only faintly golden on under side, and lightly clothed with short hairs.

Abdomen silvery and black, as usual; very hairy on ventral surface. Hypopygium very dark brown almost black, less hairy than usual. Forceps, when viewed externally, shiny black, slightly sculptured and angular, but when viewed internally they appear dark brown. They are closely approximated for over half their length, but no connecting membrane is developed. At the angle are about ten short, stout, black bristles. The upper portion is hairy. Accessory plates brown and provided with only short hairs. Claspers brown at base, shiny black towards tips. Posterior clasper long and blunt; the anterior bifurcate. The connecting membrane immediately surrounding the penis develops a small "clasper-like" process antero-ventrally. First joint of penis dark brown; the second joint considerably simpler in structure than in the other forms examined by us, almost black in colour, and provided distally with a pair of medium-sized recurved hooks (Fig. 20).

Described from one male captured on bad meat in Brisbane.

15. **Sarcophaga theta** n. sp. (Fig. 5).

General appearance very like *S. aurifrons*. Length 9 to 12 mm.

MALE.—*Head.*—Front fairly prominent, about half the width of eye. Frontal stripe nearly black, a little wider than parafrontals. Parafrontals, genæ, and back of head bright golden ; mesofacial plates silvery with golden tinge and darker borders. Epistome fairly prominent, tinged with pink. First antennal segment very small ; second shorter than usual and nearly black ; third well over thrice the length of second, and of a very dark brown colour. Eyes red-brown. Proboscis and palps as usual. Eleven frontals beside frontal stripe ; vibrissæ rather shorter than usual. Five facials, seven peristomials. Verticals present, lateral verticals absent. A single row of short black bristles behind eyes ; back of head clothed with short pale-golden hairs, developing into a beard-like growth on the lower part of the genæ, but rather sparse and short on the anterior portion of the latter.

Thorax a pale-golden colour, with the usual three longitudinal black stripes, the middle one plainly visible on the scutellum, the lateral two only very faintly so. Sides of thorax golden ; under side grey. Anterior spiracle provided with yellow hairs.

Of the anterior acrostichals only the posterior pair present, though but very weak ; posterior acrostichals entirely absent. Dorsocentral row complete, the last pair extending just to the tip of scutellum. Two intra-alars, also apical scutellars, present.

Legs black and grey. First femur golden below and lightly hairy proximo-ventrally ; tibia longer than tarsus. Second femur not hairy ; a "comb" not definitely differentiated ; tibia hairless. Third femur hairless, tibia strongly hairy.

Abdomen with the usual black and grey markings. The median longitudinal black row prominent anteriorly ; extending only faintly on to the last segment. Abdomen with short black reclinate bristles above, hairy beneath. First segment of hypopygium silvery pollinose ; second nearly black, shiny and very hairy. Forceps shiny black, a little sculptured, approximated posteriorly for about three-fifths their length ; straight almost to the tips which are fairly sharply bent,

pointed and bare; the remainder strongly hairy. Accessory plates very large, dark brown and hairy. Claspers shiny black. First segment of penis brown; second more heavily chitinised, black, in parts brown, the outer portions yellowish or whitish. It is a relatively simple organ with a pair of short forwardly directed ventral processes, and a large irregular chitinous mass above and anterior to these (Fig. 5).

FEMALE.—This differs from the male in the following characters:—Front about as wide as eyes. Lateral verticals well developed. A row of eight frontals beside frontal stripe, and three larger ones beside eye. Scutellum slightly more abbreviated than in male. Thoracic chætotaxy as in male, except that the apical scutellars are absent. Thorax moderately hairy beneath. First leg not hairy; the second femur is remarkable in that it has a well-developed "comb" of eight bristles, such a structure being here confined to the female, whereas normally it occurs only in the male. Third tibia not hairy. Abdomen a little more rounded than in male. Dorsal longitudinal line extends definitely on to last segment.

Described from a number of males and females bred from decaying meat in Brisbane in September 1920.

16. **Sarcophaga iota** n. sp. (Fig. 11).

In general appearance a medium-sized greyish-gold fly; length of the male about 12 mm., while the female is usually from 9 to 10 mm.

MALE.—*Head.*—Front prominent; over half the eye-width. Frontal stripe nearly black, and slightly less than width of parafrontals. Parafrontals golden, almost brassy in colour; genæ approximately the same colour as parafrontals. Mesofacial plate silvery, with dark borders. First antennal joint inconspicuous; second moderately large, black; third black, and about four times the length of second. Back of head golden. Proboscis dark brown, almost black, and provided with long dark-brown hairs; palps very dark brown; epistome very faintly pink, not prominent. A single row of black bristles behind eyes; hairs below these golden, short, developing into a beard-like growth ventrally; anterior part of genæ with shorter golden hairs. Verticals present; lateral verticals absent. A row of frontals beside frontal stripe. Vibrissæ not very large.

Thorax greyish gold, with the usual black longitudinal stripes, the middle one alone extending on to scutellum ; sides of thorax grey and gold ; ventral side grey. Anterior spiracle dark chocolate brown, provided with brown hairs. Of the anterior acrostichals only the last two pairs are present ; of the posterior, only the prescutellar, which are very strong, reaching nearly to the tip of scutellum. Apical scutellars present. Three intra-alar bristles present. Posterior pair of dorsocentrals reach far beyond scutellum.

Legs black and grey. First femur golden below, clothed with short hairs, tibia a little longer than tarsus. Second femur not hairy ; a "comb" differentiated ; tibia a little longer than tarsus. Third femur lightly hairy ; tibia longer than tarsus and not markedly hairy.

Abdomen with the usual black and white markings ; with short reclinate bristles dorsally, and a long beard-like growth of hairs ventrally. In the hypopygium the first segment is silvery pollinose, the second almost black and provided with long hairs. Forceps approximated for about two-thirds their length ; angular in side view, ending in a sharp point ; tip black and bare ; upper portion slightly hairy, and dark shiny brown. Accessory plate brown, rounded, and moderately hairy. Claspers very dark brown. First joint of penis brown ; second more heavily chitinised, black and dark brown, provided ventrally with a pair of hook-shaped, foliaceous processes, tipped ventrally with white (Fig. 11).

FEMALE.—This differs from the male in the following characters :—It is shorter than the male, measuring about 9 to 10 mm. ; one female reached only 7 mm. Front as wide as eyes. Lateral verticals very well developed. A row of seven frontal bristles beside the frontal stripe, and three large bristles beside eye. Scutellum much abbreviated, almost flat, whereas in the male it is strongly convex. Thoracic chætotaxy as in male ; i.e. two anterior acrostichals, three intra-alars, but no apical scutellars. Tibiæ and femora all hairless. No "comb" on second femur. Abdomen very rounded ; hairy, but not markedly so beaneath ; median dorsal black line extends on to last segment.

Bred from decomposing meat in Brisbane, October 1920.

17. Sarcophaga kappa n. sp. (Fig. 7).

General appearance like *S. aurifrons* Mcq. Length 12 mm.

MALE.—*Head.*—Front not prominent; about two-fifths the width of eye. Eyes dark red-brown; frontal stripe very dark chocolate brown, and slightly broader than parafrontals at their narrowest. Parafrontals, genæ, and back of head golden, the latter very faintly tinged with dark. Genæ distinctly paler than parafrontals. Proboscis nearly black with brown hairs; palps very dark brown. Mesofacial plates faintly golden, more greyish at sides; epistome pinkish, not very prominent. First antennal joint inconspicuous; second black, tinged with silver, and a little smaller than usual; third joint rather over four times the length of second, and of a beautiful fawn colour. A row of twelve frontal bristles present. Verticals large; lateral verticals absent. Seven facials and eleven peristomials. A single row of black cilia behind eyes; hairs below these short and golden, developed into a beard-like growth below; hairs on anterior part of cheek shorter and golden.

Thorax pale golden, with the usual three regular longitudinal black stripes, the middle one extending on to the scutellum, the laterals represented each by a pale-brown discolouration. Sides golden; ventral portion grey. Of the anterior acrostichals only the posterior pair is developed; of the posterior set only the prescutellars, and these are considerably weaker than the anterior intra-alar. Scutellar apicals present; also three humerals, the lowest not reaching to the mesonotum. Dorsocentral row normal, the last pair (prescutellar) reaching just beyond scutellum.

Legs black, femora tinged with grey. First femur hairy, tibia slightly longer than tarsus. Second femur hairy proximo-ventrally, a "comb" developed distally; tibia longer than tarsus and not hairy. Posterior femur and tibia hairy.

Abdomen as long as thorax, conical, with the usual black and white markings, the median black line extending on to last segment; hairy below. First genital segment grey and pollinose; second dark brown, almost black, hairy. Accessory plates dark brown with long hairs. Forceps shiny black, curved; tips bare, remainder hairy, especially proximally. Claspers very dark brown, and articulating with one another basally. First joint of penis dark brown; the greater part

of the second black, with parts a lighter brown and parts whitish. From the ventral side are given off a number of irregularly shaped, somewhat foliaceous processes fringed with short whitish hairs. The penis is provided laterally with two strong black hooks, closely resembling claspers (Fig. 7).

FEMALE.—This differs from the male in the following important characters :—Front about four-fifths the width of eyes ; parafrontals nearly twice the width of frontal stripe. Lateral verticals very well developed. Nine frontal bristles beside the frontal stripe ; three which are much larger beside the eye. Thoracic chætotaxy as in male, except that the prescutellar acrostichals are slightly larger in the female, and the scutellar apicals absent. First femur not hairy. Second and third tarsi and tibiæ without hair. Abdomen more rounded than in male, and with the usual markings, the median black line extending on to the last segment.

Described from several males and females bred from bad meat in Brisbane.

18. **Sarcophaga omikron** n. sp. (Fig. 16).

General appearance closely resembling *S. aurifrons*. Length 10 to 12 mm.

MALE.—*Head.*—Front moderately prominent, a little less than half the width of eye ; eyes brown. Frontal stripe black, a little narrower than parafrontals. Parafrontals, genæ, and occiput bright golden ; mesofacial plates silvery, faintly tinged with gold. Epistome inconspicuous ; first antennal joint invisible ; second large, black, coated with silvery hairs ; third joint silvery, about thrice the length of second. Arista shorter than usual, measuring only about six-fifths the length of the antennal joints combined. A row of twelve frontals beside frontal stripe ; at the upper end of this row, below the ocelli, are five other bristles, one outside the row, the others internal to it. Vibrissa inserted fairly close to oral margin. About twelve facials and eight peristomials present. Verticals not very strongly developed ; a single row of short black bristles behind eyes ; occiput covered by short golden hairs which become longer below on the genæ, but shorter again more anteriorly.

Thorax rather bright golden, with the longitudinal jet-black stripes much darker than usual ; the middle one alone has a

very prominent extension on to the scutellum. Sides grey and gold; ventral side grey; both provided with patches of long golden hairs. Shoulders with short black bristles and long golden hairs. Anterior spiracle dark chocolate, and provided with a heavy coat of short brown hairs.

Of the anterior acrostichals, only the posterior pair present, rather long but slender; of the posterior set, only the pre-scutellars. Scutellar apicals present; dorsocentral row complete, the last pair very long, the second shorter, but much stronger than those anterior to them. Two intra-alars.

Legs grey and black. The first femur bright golden beneath, and clothed with short hairs; longitudinal rows of bristles very complete. Second femur hairy proximo-ventrally; distally a "comb" is differentiated; tibia hairless, and considerably longer than tarsus. Third femur heavily clad with short hairs; distal two-thirds of tibia very hairy; distal third free; tibia longer than tarsus.

Abdomen about as long as thorax; conical, with the usual black and white markings; the dorsal longitudinal black line extends faintly on to last segment. Covered dorsally with short black reclinate bristles; hairy beneath. Hypopygium visible dorsally; first segment silvery pollinose, second shiny black and hairy. Forceps shiny black, curved, sharply pointed; tips bare, rest hairy. Accessory plates brown, hairy. Claspers simple; shiny black. The penis is a very stout organ, brown in colour, slightly pollinose, and developed distally into a short stout hook, as figured (Fig. 16).

FEMALE.—This differs from the male in the following characters:—Frontal stripe about four-fifths the width of eye. A row of nine frontal bristles beside frontal stripe, a second row of three large bristles immediately beside the eye. Lateral verticals prominent. Thoracic chætotaxy as in male, except that the scutellar apicals are absent. Scutellum considerably more rounded than in male. First femur only slightly golden, not hairy; tibia about as long as tarsus. Second and third tibiæ and femora hairless; no "comb" on second femur. Abdomen rounded, much shorter than thorax; covered dorsally with short reclinate bristles; longitudinal black line faintly visible on last segment. Ventral side scarcely hairy.

Described from specimens bred from wool by Mr. Henry

Tryon, Queensland Government Entomologist, as well as one bred by Miss M. J. Bancroft from rotten potato in Eidsvold in March 1920.

19. **Sarcophaga sigma** n. sp. (Fig. 17).

General appearance closely resembling *S. aurifrons.*

MALE.—*Head.*—Eyes dark red-brown, and very flat in front, giving the front a very prominent appearance. Parafrontals gold with dark reflections. Front half as wide as eyes; frontal stripe nearly black, a little wider than parafrontals. Genæ golden with a rather brassy tint. Occiput golden. Mesofacials silvery; epistome fairly prominent. First antennal segment not very conspicuous; second large, nearly black; third about twice length of second, nearly black. A row of twelve frontals beside frontal stripe. Verticals present; lateral verticals rather well developed. Eight peristomials and seven facials present. Three rows of short black bristles behind eyes; the first row much more regular and complete than the others. Hairs below these short and silvery, developing into a beard-like growth below. Anterior part of genæ with black bristles.

Thorax golden grey with the usual black longitudinal stripes, only the middle one extending prominently on to the scutellum. Sides grey, tinged with golden, under side grey; anterior spiracle with brown hairs. Of the acrostichals only the prescutellar pair present, though very weakly developed; three intra-alars; dorsocentral row complete; apical scutellars present; lowest humeral very large, extending just on to the mesonotum.

Legs black and grey. First femur tinged with gold ventrally, not hairy; tibia longer than tarsus. Second femur with a "comb," hairy proximo-ventrally. Third femur only slightly hairy; tibia not hairy.

Abdomen conical, shorter than thorax, with the usual black and white markings. Dorsal median line wide, but irregular, not extending on to last segment. Covered dorsally with short black reclinate bristles; hairy ventrally. Last segment of hypopygium shiny black, hairy; forceps fairly straight, bare at tips, hairy above. Accessory plate dark brown, hairy. Claspers dark shiny black. The penis is a heavily chitinised structure; the last segment nearly black, and divided distally into two parts, as figured (Fig. 17). The

posterior portion bears a long thin bent chitinous process; while laterally there is a curious tube-like structure of a pale-brown colour.

FEMALE.—This differs from the male in the following characters:—Front about four-fifths the eye-width. A row of eight frontals beside the frontal stripe, and three large bristles beside the eye; lateral verticals well developed. Three rows of black bristles behind eyes; the first row well developed; the second irregular; the third very incomplete. Thoracic chætotaxy as in male, except that the apical scutellars are absent. Legs as in male except that the second femur is not hairy and no "comb" develops; third femur not hairy. Abdomen more rounded than in male; very slightly hairy beneath, and then only posteriorly.

Described from a number of males and females bred from decaying meat in Brisbane in December 1920.

20. **Sarcophaga bancrofti** n. sp. (Fig. 8).

In general appearance a rather small form, measuring about 7 mm. in length.

MALE.—*Head.*—Front prominent; less than one-third the width of eye. Eye reddish yellow. Frontal stripe very dark chocolate, wide below, but narrowing off towards the ocelli. Parafrontals pale golden above and beside the frontal stripe, the remainder silvery and heavily pollinose. Mesofacial plates a beautiful dark ferruginous colour; genæ and metacephalon bright golden. The three antennal joints of a brilliant ochre; first joint clearly visible; second usual size; third over twice the length of second. Arista plumose for well over half its length, and not very much longer than the three antennal joints combined. Vibrissæ inserted close to oral margin. Six facials, eight peristomials, and a row of ten frontals present. Verticals not very strongly developed. Two rows of black bristles behind eyes; the lower row rather incomplete. Back of head coated with silvery hairs, which become longer below, but do not develop into a beard-like growth. Cheeks coated with black bristles. Proboscis as usual; palps like antennæ.

Thorax golden with the usual longitudinal black stripes, which do not extend on to scutellum. Lateral and ventral

parts grey. Anterior spiracle very small, clad with hairs which have a pinky tinge. Of the anterior acrostichals, only the posterior pair present; of the posterior acrostichals only the prescutellar occur and are rather well developed. Scutellar apicals present. Dorsocentral row complete. Four humeral bristles; anterior post-humeral does not reach beyond pronotum; second post-humeral a little smaller than first.

Legs black and grey. First femur not hairy, tarsus somewhat longer than tibia. Second femur not hairy, "comb" not clearly differentiated; tibia not hairy, longer than tarsus. Last leg not hairy. Pulvilli dark brown, fringed with silver.

Abdomen long and conical; the large anterior segment with a median triangular black patch; grey laterally, bordered with black; other segments with an indefinite black line along the back, dark brown beside this, bordered with a pair of anterior white and posterior black patches in each segment. Covered dorsally with short reclinate brisues; not hairy below, but clothed with short weak bristles.

First segment of hypopygium black, with faint silvery bloom; second segment black, very faintly ridged, and very slightly hairy. Forceps black; lightly hairy; rather thin and weak; not sharply pointed. Accessory plate somewhat triangular, hairy. Claspers dark shiny black, simple, the anterior pair larger than the posterior. The penis is a heavily chitinised structure; first joint shiny black, white ventrally; second joint nearly square in side view, provided anteriorly with a stout rather sharp hook, and posteriorly with a pair of yellowish brown processes (Fig. 8).

Described from a male caught in open forest country in Queensland National Park, in January 1921. The species is dedicated to Dr. T. L. Bancroft and his daugher M. J. Bancroft, Eidsvold, who have assisted us so freely in regard to material.

21. Sarcophaga (Parasarcophaga) omega new subgen., n. sp. (Figs. 25, 26).

MALE.—*Head* (Fig. 26).—Front exceedingly prominent. Frontal stripe about thrice the width of the parafrontals, and pitchy black in colour, a little folded, and very minutely punctate. In the region of the ocelli it narrows; but below it widens out, developing into a pair of prominent folded excres-

cences, which protrude well in front of the antennæ, surround the mesofacial plate, and gradually die out at the oral margin. Front slightly under three-fifths the width of eye; genæ, metacephalon, and parafrontals brightly golden pollinose. First antennal joint concealed; second rather large, pitchy black, slightly punctate, with a few small bristles; third joint black, with a very faint silvery bloom, and about two and a half times the length of second. Mesofacial plate golden, with darker borders. Cheek height about two-fifths that of eye. Eye rather small, dark red-brown. A single row of ten rather small frontal bristles present; verticals large; lateral verticals absent. A single row of black bristles behind eyes; metacephalon covered with short pale-golden hairs, growing much longer below on the genæ; anterior part of genæ lightly clothed with pale-golden hairs. Proboscis and palps as usual.

Thorax at its broadest about the width of the head; colour rather ashy, faintly golden, with the usual three very dark brown longitudinal stripes, the middle one alone extending on to scutellum. Anterior spiracle large and clothed with pale-golden hairs. Sides grey and golden; under side grey and golden, the former predominating. Of the anterior acrostichals only the posterior pair is well developed; of the posterior set, only the prescutellars are differentiated, being rather large. Dorsocentral row normal; apical scutellars well developed; two intra-alars present. Three humerals, the lowest extending just beyond pronotum; a single post-humeral.

Legs black and grey. First femur golden beneath; longitudinal rows of bristles complete; femur only very slightly hairy proximo-ventrally; tibia not hairy. Second femur clothed with short hairs proximo-ventrally; a well-defined "comb" present; tibia longer than tarsus. Last femur heavily clothed with short hairs; distal two-thirds of tibia hairy; tibia longer than tarsus.

Abdomen conical and rather longer than thorax, with the usual black and white markings, the longitudinal black line not extending on to last segment. Upper surface with short reclinate bristles; lower surface moderately hairy.

First segment of hypopygium black, faintly golden pollinose, hairy; second segment rather small, shiny black, very hairy. Forceps shiny black or very dark brown, faintly sculptured, sharply pointed, hairy; upper half approximated,

points converging towards each other. A moderately developed connecting membrane present. Accessory plate brown, hairy. First joint of penis dark brown ; second somewhat like that of *Sarcophaga froggatti*, though more elongated.

Described from one male, caught on decaying meat in Brisbane, April 1921.

This species is distingufshed irom all other Sarcophagids known to us by the above-mentioned very prominent excrescences on the head. As all the remaining external characters are of the ordinary *Sarcophaga* type, we are placing this form in a new subgenus *Parasarcophaga* which may be provisionally diagnosed as follows :—*Male*: General characters as in *Sarcophaga* ; but frontal stripe about three times the width of the parafrontals whereas in the males of *Sarcophaga* it is seldom more than twice ; frontal stripe developed into a very large lobed prominence forming an arch around the mesofacial plate. Type species, *Parasarcophaga omega*.

LIST OF FIGURES.

With the exception of No. 26, all figures are freehand drawings of male copulatory organs :—1, 2, two different ventral views of *S. irrequieta* ; 3, lateral view of same ; 4, *S. aurifrons* ; 5. *S. theta* ; 6, *S. beta* ; 7, *S. kappa* ; 8, *S. bancrofti* ; 9, 10, *S. tryoni* ; 11, *S. iota* ; 12, *S. froggatti* ; 13, *S. delta*, penis only ; 14, *S. eta* ; 15, *S. gamma* ; 16, *S. omikron* ; 17, *S. sigma* ; 18, *S. impatiens* ; 19, *S. impatiens*, penis only ; 20, *S. zeta* ; 21, *S. alpha* ; 22, *S. misera* ; 23, *S. dux* ; 24, *Helicobia australis* ; 25, *S.* (*Parasarcophaga*) *omega*, penis only ; 26, *S.* (*P.*) *omega*, front view of head.

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THE MAGNIFICENT SPIDER: *DICROSTICHUS MAGNIFICUS* RAINBOW.

Notes on Cocoon Spinning and Method of Catching Prey.

By Heber A. Longman, F.L.S.

(Plates VII and VIII.)

(*Read before the Royal Society of Queensland, 25th July, 1921.*)

The following observations are the result of several months of study of the "Magnificent Spider," *Dicrostichus magnificus*, specimens of which have been transferred to my garden in Brisbane. The so-called cocoons or egg-bags of this spider are such remarkable objects that they are frequently brought to the Queensland Museum. The children call them "cow's teats." As the spiders are practically stationary in the adult stage, they can be studied at leisure if established in a garden. Apparently no observations have been previously made on the spinning of the large cocoons, or on the remarkable way in which these spiders catch their prey, as described in this paper.

The adult female of *Dicrostichus magnificus* is a very large and handsome spider. A detailed description was given by Rainbow (1), and need not be repeated here, in view of my illustrations.

The abdomen is cream-coloured above, with darker vermiculations and a mosaic of fourteen salmon-pink spots on the front edge; the two prominent tubercles are yellowish. The dainty little turret on the cephalo-thorax, forming Simon's generic character (2), has an alabaster base, and the wine-coloured turret itself supports two pairs of eyes.

Although the locality for Rainbow's type was Mount Kembla, N.S.W., there appear to be no special distinctions in our Queensland specimens.

Apparently the different species of *Dicrostichus* manufacture distinct types of cocoons, but the contours of those associated with *D. magnificus* vary considerably. Rainbow figured cocoons with a very blunt terminal portion or tail.

In a series of seven in the same bunch in the Queensland Museum, much variation is to be noted. As may be seen from the illustrations, the cocoons are more or less elongate-fusiform. Sáville Kent illustrated a similar cocoon (unnamed) in Chromo Plate IX, "The Naturalist in Australia," 1897.

The cocoons made by the specimen in my garden showed variations ranging from 3 to 4 in. in length, the maximum diameter being about an inch. In a cocoon 4 in. long, the peduncle occupied about one quarter of the total length, and the tail or terminal portion also about one quarter, this being the most variable part.

The inner cocoon hangs centrally in the upper half of the outer envelope, being elegantly pear-shaped, with the globular end downwards. Between the two envelopes when the cocoon is opened will be found a loose packing of delicate silk, which doubtless forms a valuable elastic medium, protecting the inner cocoon with its precious freight of eggs. The texture of the inner cocoon is similar to fine rice-paper, and it is much whiter in colour than the other. Within there is a quantity of fine, loose silk surrounding the eggs. The contents of an injured cocoon were counted, over 600 eggs being present. Taking five cocoons as the average, each spider lays in a season about 3,000 eggs.

Our spider made its home in a rose-bush. By binding a number of leaves together it formed a large retreat or nest, which it completely lined inside with silk webbing. During the daytime it was invariably to be discovered in this retreat with its head turned away from the opening. An angle between two branches formed an appropriate setting for the series of cocoons to be spun. The shelter of the foliage was increased by a small leafy branch, placed in position by my wife, which the spider promptly made use of the next night and secured by silken strands. A fallen rose-petal was also worked by the spinner into its bower.

Two cocoons were spun in the earlier months of the year, but no notes were then taken. Subsequently our interest was so aroused that each night, so far as possible, the spider was watched, for we were determined to see the wondrous spinner at work. With the third cocoon we were unlucky, for it was spun during our absence on the night of 31st March, shortly after the full moon.

On the 7th April there was a domestic tragedy, for a large immature Orthopteron, noted by Mr. H. Hacker as belonging to the family Gryllacridæ (locally called "a cricket"), was discovered eating the eggs from the third cocoon. It had torn away both envelopes and had also broken the top part of the second cocoon. The spider was hanging close by, apparently quite unable to protect its eggs.

Ballooning.—On the 16th April, a fine moonlight night, tiny spiderlings (about 2 mm. in diameter) were found to be emerging from the first cocoon through a hole in the upper part which was just large enough to enable them to struggle through. When they emerged they climbed to the top and on to the surrounding leaves and roses. Spinning fine threads which floated away on a gentle breeze, they were seen ballooning through the air to start life on their own account. Often the tiny threads would get entangled and three or four spiderlings would form a little constellation among the leaves. For the next four days these small adventurers were still emerging, mostly at night. Some were noticed to float up almost vertically. Two or three were located on the upper branches of shrubs on the other side of the garden, but all were eventually lost sight of, probably being devoured by the omnivorous sparrows. What number, if any, of these tiny aeronauts survived, I dare not suggest. My observations on isolated cocoons show that the spiderlings are able to penetrate the tough outer envelope of the cocoon and escape without any assistance from the mother. Examination of cocoons from which the spiderlings had all emerged showed that they contained the débris of initial ecdyses.

Spinning the Cocoon.—On the night of 21st April our persistent watching and waiting were rewarded. Shortly after sunset the spider was noticed to be busy, and quite a different creature from the almost motionless object of previous nights. She had chosen a perfect moonlight night for her toil. At first her object was not apparent, for she was at work among the supporting strands near the old cocoons. By letting herself down she spun a strand, up which she then climbed, taking it with her and attaching the line horizontally. She repeated this until many supports were formed for the dainty home of the new brood. Then the spider slowly spun a vertical strand by letting herself down from the upper supports. Although thin, this strand was, as will be

subsequently shown, of surprising toughness. At the end of this line she was suspended, and at 8.30 we noticed that the great work of spinning the cocoon was actually commenced. A tiny sheet of web was spun out from the end of the central strand. At 9 o'clock this was apparent as a little oval tent over the spider's back, to which she, ever spinning, added to the circumference. In weaving this ever-growing sheet, she twisted from side to side, the central strand rotating at her will through two-thirds of a circle, and then returning. At 9.30 the spider was half enveloped in a filmy cloud, as it appeared in the moonlight, and the sheet was being gathered into a bag. Into this bag the eggs were then laid with marvellous quickness, the whole operation taking but a few minutes. The eggs formed a glistening, globular mass about three-eighths of an inch in diameter, and this could be easily seen through the substance of the inner cocoon. During the process the spider's abdomen was inside the opening in the bag. Immediately afterwards, the mother was seen to have lost her great bulk, and the abdomen appeared to be wrinkled. At 9.45 the spider was hard at work filling the slit in the bag through which the eggs had been laid. Did she leave a weak place for the exit of the young, one wonders ? At 10.30 the inner capsule was finely woven over and complete.

For the next hour the spider was unceasingly engaged in building up a fluffy packing around and below the inner cocoon. In this particular instance, quite a long tail, or apical portion, was spun, but the work on this part varies considerably in different egg-bags, and is probably dependent on the immediate surroundings of the cocoons. This fluffy packing is built up until its contours take the final shape of the cocoon.

The colossal task of weaving the large outer capsule was then commenced. This is by far the most arduous portion of all the mother's labour. The outer envelope has to be made strong enough to protect the precious inner cocoon from the weather, from friction when blown against leaves and branches, from the attacks of predaceous insects, and from the ovipositors of parasitical insects. Under magnification, its finished texture is seen to be very closely woven, and the final result is a tough material, not easily torn or penetrated.

During the long process of spinning this outer envelope, the spider worked from top to bottom, head downwards,

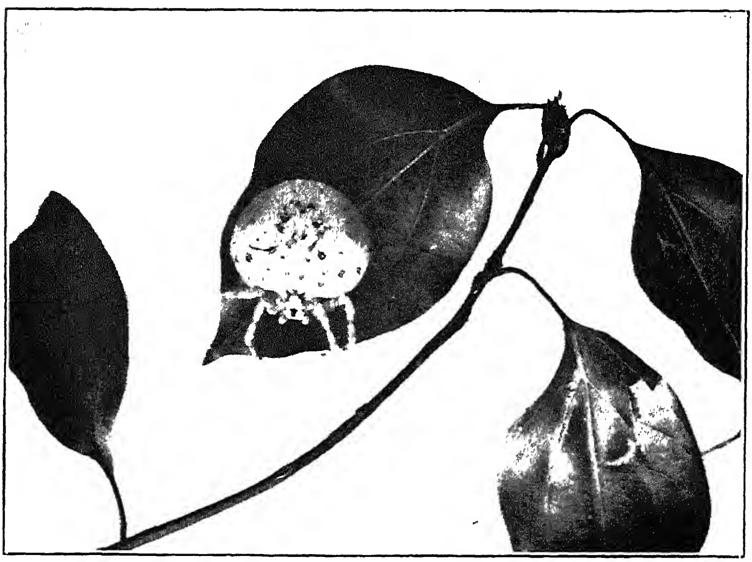

Figure 1.—*Dicrostichus magnificus*, ♀, from life.
(Natural size.)

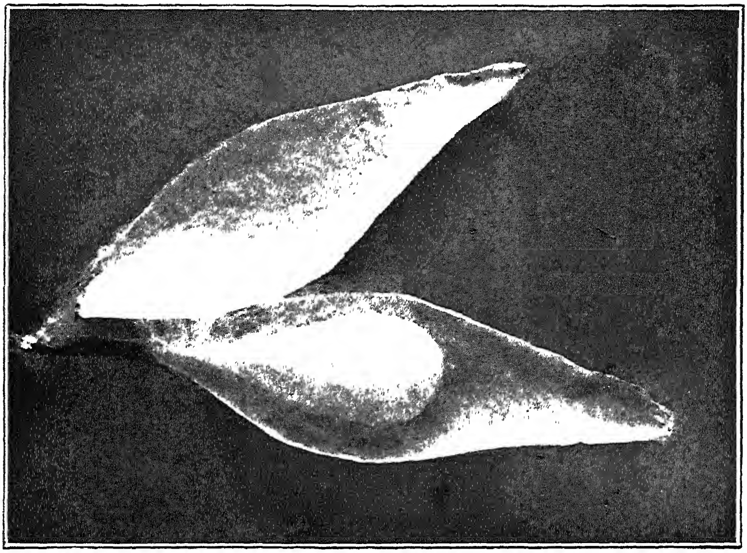

Figure 2.—Cocoon sectioned to show structure.
(Natural size.) *Photos: H. Hacker.*

and then from bottom to top, on the other side, head upwards. It supported itself by gripping the cocoon with its legs meanwhile. Against the light the minute silk threads issuing from the spinnerets could be seen as a shining band of conjoined lines. The legs were in no way used to manipulate the threads but the body was moved up and down, up and down, making a stroke of about three-eighths of an inch. One touch of the protruding spinnerets on the cocoon sufficed to attach the strands. The spider moved with surprising quickness, its spinning stroke varying from about 60 to 80 spins per minute. During its journey up and down the capsule 260 spinning movements were counted, and this represented but a single narrow sector of the whole circumference. Some idea of the energy expended by the toiling mother in her great work may be gauged from these figures, and one wonders at the strength of the muscles which move the abdomen. With haste and without rest, the process was continued, and at midnight the cocoon had attained its final contours. The spinning on the outer surface then reached a finer stage, and the glossy waterproofing was being done. Instead of working in vertical lines, the threads were attached from side to side as the spider made its way down and then up the capsule. This lateral movement was very noticeable, and the resultant spinning added to the toughness of the material, giving a criss-cross weaving. The whole surface of the cocoon had been woven over many times.

By 1 o'clock the capsule was smooth and glossy, but the spider was still working up and down, making short spins from its apparently inexhaustible reservoirs, the threads being attached by lateral movements of the abdomen.

During the whole process up to this time, the spider and cocoon were suspended by the tiny vertical cable which appeared to be perilously slender, and which swayed with every movement of the spinning mother. At 1.30 the spider was working at the upper half of the cocoon, which it cleverly rotated through three-quarters of a circle as it spun, moving the cocoon instead of its abdomen. At 1.45 it commenced to strengthen the slender supporting strand, somewhat to the relief of the weary though keenly interested watchers. For the next half-hour it worked at this peduncle, moving up and down and occasionally partly rotating it, getting a criss-cross effect with its weaving. It also climbed several times up among the supporting horizontal strands adding to the attachments.

At 2.30 it was still working at the peduncle, occasionally finishing off its spins near to the centre of the cocoon. The peduncle of the cocoon was now nearly one-eighth of an inch in diameter, and this was slightly expanded again at the very top, where attachments were made.

At 2.45 the spider stopped spinning for the first time during the whole process, so far as we could see from our almost continuous observations. She rested on the peduncle for about ten minutes, and then she proceeded to test the supporting strands, adding several to the surrounding leaves and twigs. This work was continued until 3.20. Lines were taken far back among the surrounding leaves and these were bound together, as though the spinner were aware that they might otherwise fall off and imperil the whole structure. Possibly this extra work was necessary because the cocoons were hanging with plenty of space between the angle of the two branches. Attachments were made to the top and to lower portions of the peduncle, so that the cocoon could safely swing in the wind without breaking a thread. Like a skilled engineer, the spinner went carefully over her work, testing, adding, strengthening, as though determined to make it as secure as was spiderly possible. For short periods she remained quiescent, but it was not until 4 o'clock that she was fully satisfied and moved slowly along her lines to the cosy retreat.

It is astonishing to see the powers and the limitations of instinct. This skilful spinner had apparently neither the art nor the inclination to mend the rent in her cocoon when it was torn by the Gryllacrid.

Probably her far-off ancestors were content to spin a simple cocoon with but one envelope. And even with the double shield but few of these spiders survive, for they do not appear to be very common. Nature is ever prodigal with her resources, and it may be that, of all the progeny of this night of spinning under the moon, but one or two will survive the perils of ballooning when they emerge on their fearless flight.

The fifth cocoon was spun on 7th May, fifteen days afterwards, on a dark, moonless night. The sixth was made on 23rd May in threatening weather, the spider apparently hesitating until after 10 o'clock whether or not to spin. On 14th June the seventh and last cocoon of the season was made, this being only two-thirds the size of the others.

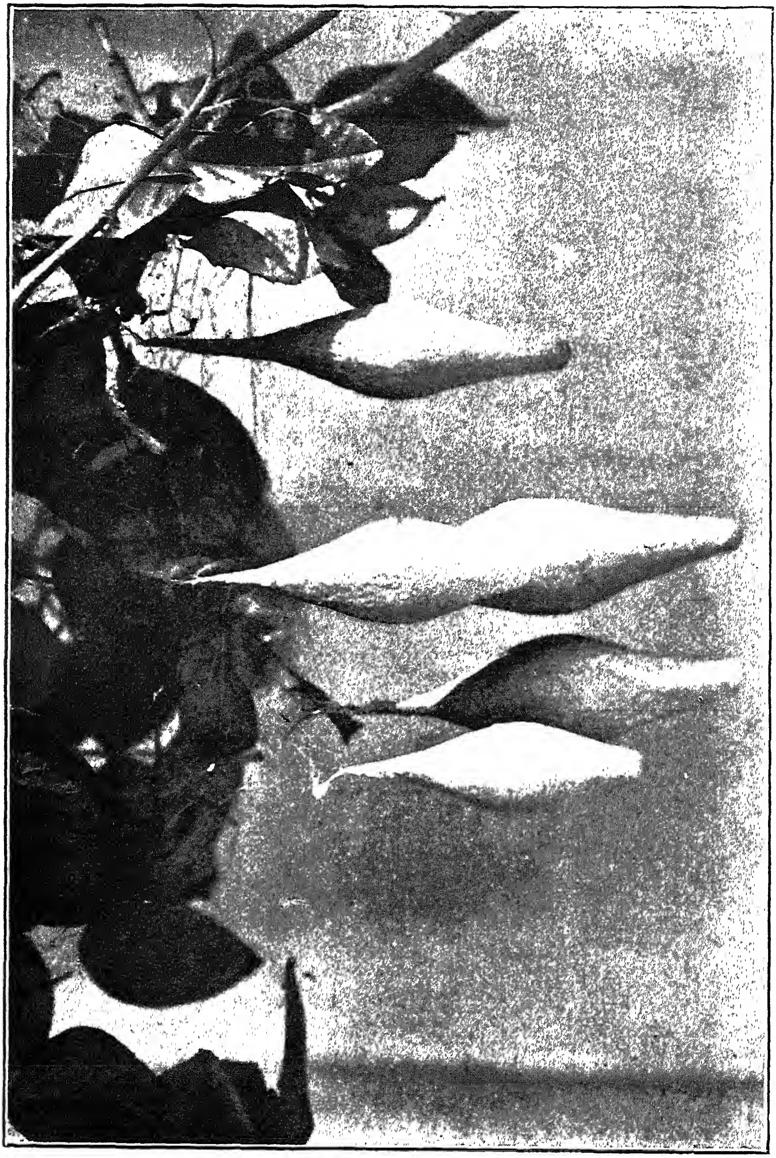

Photo: H. Hacker.

Cocoons of *Dicrostichus magnificus*.

Spiderlings from the cocoon made on the 21st April did not emerge until the 25th July.

Remarkable Method of Catching Prey.—Rainbow referred to the retitelarian nature of the web of this spider (3), but my observations definitely show that *Dicrostichus magnificus* does not catch its prey in a web, at any rate in the cocoon-making season. Except for the many supporting strands for the cocoons, and the simple lines by which it suspends itself, which are also connected with the closely woven retreat, no other web is spun. None of these lines are sticky and no insect can be caught on them. There is no web entanglement to trap the moths on which it feeds. Shortly after sunset, the spider hangs suspended on a more or less horizontal line near to its cocoons. My wife and I repeatedly found it sucking a common species of Noctuid moth (*Remigra frugalis* Fabr.) which it had secured in some mysterious way. Close and persistent watching through many nights revealed the remarkable method by which it caught them. From its slender bridge it would spin a filament, usually about one and a-half inches in length, which was suspended downwards: on the end of this was a globule of very viscid matter, a little larger than the head of an ordinary pin, occasionally with several smaller globules above. This filament was held out by one of the front legs, the miniature apparatus bearing a quaint resemblance to a fisherman's rod and line. On the approach of a moth, the spider whirls the filament and globule with surprising speed, and this is undoubtedly the way in which it secures its prey. The moths are unquestionably attracted to an effective extent by the spider, whether by scent or by its colour we cannot say. We certainly could not distinguish the slightest odour. But the fact remains that night after night one or two moths would flutter up and be caught. Other moths near by seemed to be indifferent, but two were often secured in the space of an hour, one of which would be packed away on the line to be sucked later. The spectacle of the moth fluttering up to the spider, sometimes two or even three times before it was caught, is one of the most interesting little processes which the writer has ever witnessed in natural history. The supposed desire of the moth for the star is a poet's fancy, but the attraction of the moth to the *Dicrostichus*, although mysterious, can be seen by any patient watcher.

The globule is composed of most tenacious material, and quite large leaves can be suspended on it by a mere touch.

The spider can be artificially fed by holding a moth to the hanging globule, to which it can be transfixed by the slightest contact. Occasionally the filament and globule will be drawn up and another manufactured. The spider will ignore a moth which is artificially placed along its lines, and apparently its one method of catching them is by the filament and globule. The moth is as helpless when touched by the globule as is a fly on fly-paper. When the insect is secured on the sticky globule it is pulled up, and apparently killed by an injection of venom ; it is then neatly bound in a little bundle, leisurely placed in line with the spider's head and there held and sucked, the wings being ultimately discarded.

Probably the study of allied species will reveal other stages in the evolution of this curious habit. *Celænia excavata*, which makes small spherical cocoons, is also without a web.

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(2) 1892. E. Simon.—Hist. Nat. Araignées, pp. 883, 886.
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On the Biology and Economic Significance of the Chalcid Parasites of Australian Sheep Maggot-flies.

By Professor T. Harvey Johnston, M.A., D.Sc., and O. W. Tiegs, M.Sc., Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(Plates IX. and X.)

(*Read before the Royal Society of Queensland, 25th July, 1921.*)

Sheep maggot-flies are amongst the commonest and most widely spread insects in Australia. When one takes into consideration the extensive degree of parasitism exhibited by Hymenoptera upon other insects, it might reasonably be expected that numerous species would be found which depend for their existence on this abundant food supply. A number of such wasps have actually been discovered in Australia, mainly by Mr. W. W. Froggatt, of Sydney. In the present paper three other primary parasites of sheep blowflies are recorded. Careful search would, no doubt, reveal the presence of other species.

The forms hitherto recorded are—(1) *Nasonia brevicornis* Ashmead; (2) *Dirhinus sarcophagæ* Froggatt; (3) *Chalcis calliphoræ* Froggatt; (4) *Hemilexomyia abrupta* Dodd. The following forms in addition to Nos. 1, 2, and 3 have been found parasitizing either the larvæ or the pupæ of blowflies in Brisbane under natural conditions:—(5) *Spalangia muscidarum* Richardson; (6) an Encyrtid wasp, for which the name *Australencyrtus giraulti*, n. gen., n. sp., is proposed; (7) and a Proctotrypid (Diapriid) wasp, apparently also new, for which we propose the name *Paraspilomicrus froggatti*, n. gen., n. sp. (8) An eighth species, *Pachycrepoideus dubius* Ashmead, has been recorded by Girault from North Queensland, where no doubt it parasitizes Muscoid flies, as elsewhere. (9) Probably *Chalcis dipterophaga* Girault & Dodd is a parasite of blowflies.

In the present paper we give (A) an account of the biology of some of these forms, together with some general remarks on each species; (B) a discussion of the rôle they can be made to play in the control of the sheep flies; (C) a description of two apparently new wasp parasites of Australian blowflies.

Some information relating to these hymenopterous parasites of flies has been recently published by one of us (Johnston, 1921).

A.—OBSERVATIONS ON THE BIOLOGY OF THE CHALCID PARASITES OF AUSTRALIAN SHEEP BLOWFLIES.

The chalcid wasps that parasitize sheep maggot-flies may be divided into two groups according as they attack the pupa or larva. Egg parasites have not yet been discovered. To the former group belong *Nasonia brevicornis*, *Paraspilomicrus froggatti*, *Spalangia muscidarum*, *Dirhinus sarcophagæ*, *Pachycrepoideus dubius*, and *Hemilexomyia abrupta*; to the latter group, *Chalcis dipterophaga*, *Chalcis calliphoræ*, and *Australencyrtus giraulti*.

1. **Nasonia brevicornis** Ashmead. (Figs. 5, 6, 7, 20, 21, 22, 27-33.)

A full description of this species was given by Girault and Sanders (1909-1910). Its presence in Australia was detected by Girault in October, 1911; two years later it was found by Mr. Froggatt in N.S.W. and by Mr. E. Jarvis in Longreach, Central Queensland.

The wasp occurs very commonly in Brisbane, and can generally be easily attracted by exposing decaying meat. Careful observations on its life-history have been carried out by W. W. Froggatt and T. McCarthy (1914, 1915), as well as by J. L. Froggatt (1919). A more complete account which includes the observations of these authors has been given by Altson (1920). Graham-Smith (1919) also refers to this insect in his work on the parasites of common house-flies. (*See also* Johnston and Bancroft, 1920; Johnston, 1920.)

In the following account, therefore, only a very brief summary of published observations, supplemented by others of our own, will be given.

Length of Life-cycle.—Various observers have obtained varying results; Girault and Sanders give 15-22½ days, according to the season, in America; W. W. Froggatt and McCarthy 11 to 15, and J. L. Froggatt gives 11-14 days, in N.S.W. In Brisbane, during November, the total period was found by us to vary from 11 to 14 or even as much as 16 days, while in January and February it occupied about 14 days. Altson found that under laboratory conditions with a mean temperature of 20° C. it averaged 21 days in London.

Oviposition.—The wasps are readily attracted to carrion,

and are frequently seen sitting on the breeding-jars, or walking over the soil in search of pupæ. When a suitable pupa is found the wasp walks over it, testing the shell with its antennæ, and when a favourable spot has been found inserts its ovipositor (figs. 5, 6, 7), taking up the curious attitudes that have been described by various workers. During the process of piercing the pupal shell an oily fluid is seen running down the ovipositor, evidently acting as a lubricant. During oviposition, which lasts from a few minutes to a quarter of an hour (or even 25 minutes, Froggatt and McCarthy; 30 minutes, Altson), a number of eggs, generally about 15 to 20, but sometimes only one or two, are deposited on the surface of the developing fly (fig. 29). On several occasions it was observed that, although the ovipositor had been inserted for quite a long time, no eggs were deposited. The ovipositor is a moderately long structure, and, as it is inserted to its full length, the wasp places the eggs in clusters, sometimes at a considerable distance from the puncture.

Egg (fig. 27).—The egg is whitish and somewhat transparent, measuring, when freshly laid, about ·32 mm. in length by ·08 to ·12 mm. in breadth. It appears to contain a small amount of yolk. During development the egg frequently lengthens a little. The duration of the egg period is exceedingly important economically (as will be described more fully below), and, according to published observations, varies from 30 to 74 hours. The time in Brisbane in midsummer was found to be 40 hours.

Larva.—This, on hatching, is a small whitish maggot about ·3 mm. long, which maintains the same general appearance throughout larval life. The larvæ do not appear to move far from their original source of attachment, but can be seen clustered together where the eggs were originally placed (fig. 20). Here they appear to remain throughout the feeding period, which is about 4½ to 5 days (7 to 10 in London, Altson). The three instars are easily recognisable by the structure of the jaws, which in the first instar are long, slender, slightly curved, stylet-like structures, serving to penetrate the epidermis of the developing fly (fig. 30). The larva of the second instar is much larger than that in the first stage (fig. 31); the jaws are more powerful, and the whole larva appears much more heavily chitinised (fig. 32). The jaws of the larva

in its third instar are quite different, being much sharper piercing structures, transversely arranged (fig. 33). The fully grown larva varies in length from 1·3 to 2·4 mm.

Feeding takes place by the suctorial action of the mouth applied to the original puncture. Two sets of larval muscles appear to take part in this, a sphincter set surrounding the end of the head and evidently serving to protrude the pharynx, and a retractor set inserted into the pharynx and serving to withdraw it (fig. 32). During the feeding stage the intestine remains closed distally. The larva then undergoes a resting period (propupal stage) at the end of which it empties the intestine, the larva (fig. 21) changing from dirty grey to pure white. After about 22 hours it moults, and a whitish pupa appears, about 1½ mm. in length (fig. 22). About two days later the eyes turn reddish, on the next day they are bright red; on the following day the anterior half of the pupa turns black, and on the last day the mature wasp may be seen, within the pupal skin. The whole pupal period lasts about six days in Brisbane (five in N.S.W. according to Froggatt and McCarthy). Altson states that in London the period of development of the larva occupies 7 to 10 days from the time of hatching, with a propupal stage of 1 to 3 days, the pupal stage being 8 to 12 days (1920, pp. 219, 220). Girault and Sanders give 9 days as an average (U.S.A., springtime).

The males generally hatch first and can be seen on or near the fly-pupa, waiting for the females to emerge. Fertilisation takes place immediately, and in about six hours (3 to 24, Girault and Sanders) the females are ready for laying. Unfertilised females also oviposit quite readily, the offspring being entirely males. The females will oviposit for about three weeks. Observations by Girault and Sanders and by Froggatt and McCarthy show that on an average one female may deposit 113 eggs, but unfortunately she distributes them only amongst 17 to 20 pupæ (on an average) so that her destructive action is considerably limited. The wasp thrives fairly well in the Australian climate, and has established itself over wide areas of N.S.W. and Queensland. Froggatt and McCarthy (1914) mentioned the following blowflies as hosts:—*Calliphora villosa* (= *Neopollenia stygia*), *C. oceanicæ* (= *Paracalliphora augur*), *C. erythrocephala*, and *C. rufifacies*. J. L. Froggatt (1919) added to the list *Lucilia sericata*, *Sarcophaga aurifrons*, *Ophyra nigra*, and *Pycnosoma varipes*, the last-named two being

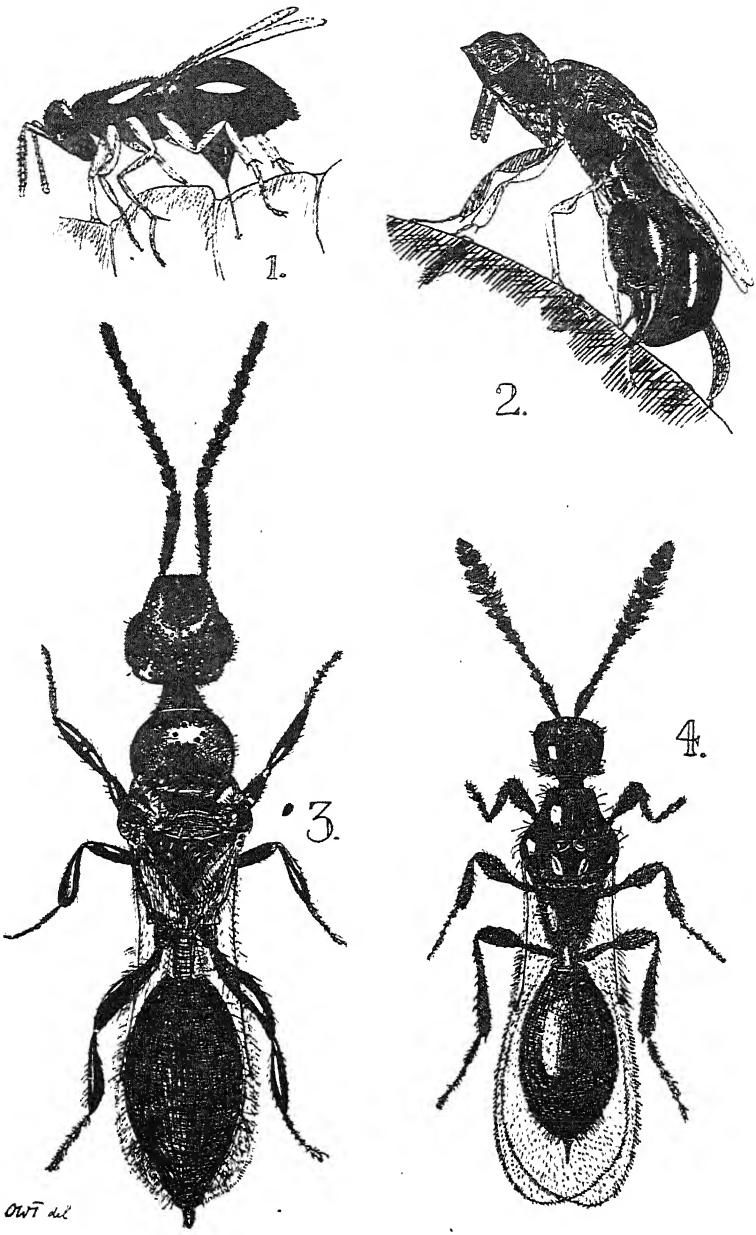


Fig. 1, *Australencyrtus giraulti* ovipositing in maggot; 2, *Dirhinus sarcophagæ* ovipositing in pupa; 3, *Spalangia muscidarum* (from Burnett River); 4, *Paraspilomicrus froggatti*.

less readily selected by the chalcid for parasitism than the others mentioned. Johnston and Bancroft (1920) added *Musca domestica*, *M. vetustissima*, *M. hilli*, and *M. terræ-reginæ*. Altson (1920) gives a list of British hosts. No less than eight species of flies (*Musca domestica* and seven blowflies) are mentioned by Girault and Sanders as capable of becoming parasitized by *Nasonia*.[1] We have found the wasp able to parasitize, in addition, the pupæ of the various species of *Sarcophaga* recently described by us as breeding in carrion (*S. aurifrons*, *S. impatiens*, *S. irrequieta*, *S. misera*, etc.)

2. Paraspilomicrus froggatti Johnston and Tiegs.
(Figs. 4, 7, 8, 18, 19.)

This Proctotrypid was first obtained from naturally infected *Lucilia* pupæ in November, 1920. A number of wasps (eight altogether) were bred from a single pupa.

Fertilisation takes place soon after hatching. The male sits upon the female, the long antennæ intertwining and undergoing a short vibration every few seconds, producing a most ludicrous effect. During oviposition the wasp adopts a curious arched attitude (fig. 8), the egg-laying process lasting about ten minutes. No developmental stages have been observed by us.

This wasp was seen around Brisbane in October and November, 1920, and again in April, 1921, but never commonly. A description of this apparently new genus and species is given at the end of this paper.

3. Spalangia muscidarum Richardson. (Fig. 3.)

This wasp was first recorded from Australia by Johnston and Bancroft (1920), who found it parasitizing various flies (*Musca* spp. and *Stomoxys calcitrans*) in Eidsvold, Burnett River, Queensland. They stated that in captivity females would parasitize *Pycnosoma rufifacies*, *P. varipes*, *Paracalliphora augur*, *Chrysomyia dux*, *Sarcophaga* spp., as well as other sheep and carrion flies. We have also seen a number of these wasps bred from *Lucilia* pupæ from Roma, by Mr. F. Taylor; also some in the U.S. National Museum, Washington, bred from *Musca domestica* in Adelaide and forwarded by Mr. A. M. Lea. During February this wasp appeared attacking the large golden species of *Sarcophaga* (*S. impatiens*, etc.) in Brisbane. It is, then, one of the natural enemies of sheep maggot-flies.

[1] A paper dealing with the biology of *N. brevicarius* has been published by E. Roubaud (Bull. Sci. France and Belgique 1917, pp. 425-439—abstract in Rev. Appl. Ent., B, 5, 1917, pp. 157-9).

The total period from egg deposition to the emergence of the wasp was 21 to 28 days during midsummer, and never more than one wasp developed from a single pupa (Johnston and Bancroft, 1920). With *Sarcophaga impatiens* during February the period varied considerably, being between 23 and 30 days; and no more than one wasp appeared from even these large pupæ.

This chalcid appears to be widely distributed over Southern Queensland, though probably not common.

4. Dirhinus sarcophagæ Froggatt. (Figs. 2, 10, 23, 24, 34.)

This wasp was first described and figured by Froggatt (1919), who bred it from pupæ of *Sarcophaga aurifrons* Macq. It occurs also in Brisbane and is most common about February. It will parasitize any of the common sheep-fly pupæ, *Pycnosoma* (both species), *Lucilia* spp., and *Sarcophaga* spp. being readily attacked. During oviposition the wasp assumes a most remarkable, uncouth attitude (fig. 2), remaining in this position for about fifteen minutes, and seems oblivious to everything going on around it, so that the pupa with the parasitizing wasp can readily be lifted without disturbing the latter. After oviposition is completed the wasp settles on the pupa in a crouching attitude for a long time, and then wanders off, usually to attack another.

The egg measures ·68 mm in length and ·17 in breadth (fig. 34). The egg period has not been observed. The maggot is a large whitish legless creature (fig. 23; Froggatt, 1919, p. 854, fig. 1) which feeds on the outside of the fly-nymph just as *Nasonia* does. It measure from 3 to 4 mm. in length.

The third instar does not appear to possess jaws. Its head is a curious structure and is provided with two prominent lips (fig. 10), the action of which causes the liquid contents of the disintegrating fly larva to flow into the mouth. The larvæ appear to be predaceous; for on several occasions two larvæ were found within a fly-pupa, yet not more than one wasp was observed to emerge from each fly-pupa. The wasp-pupa is a large white creature (fig. 24), with the characteristic *Dirhinus* appearance. The pupal period has not been determined but it is more than 7 days. The total period from oviposition to emergence during November, 1920, was found to be 25 days; but during January, 1921, as much as 28 days.

Mr. Froggatt regards this wasp as being capable of digging well beneath the soil in search of *Sarcophaga* pupæ. This is probably not the case. Sarcophagid flies pupate just as frequently on the surface of the soil as do the other carrion-flies, and it is doubtful whether the wasp would trouble to attack those beneath the surface of the soil, when there are more accessible pupæ available. On one occasion this alleged habit was tested. Soil containing pupated larvæ was put into a bottle, together with a female *Dirhinus*; she could easily have reached them by a little digging (the soil being about one inch in depth), but took no notice whatever of the buried pupæ, and after a few hours' captivity spent all her time in trying to escape.

5. **Pachycrepoideus dubius** Ashmead.

This wasp was first described from U.S.A., where it parasitizes the house-fly. It has been recorded by Girault from Northern Queensland, but nothing further is known about it in this country. Undoubtedly it attacks various flies occurring in that locality.

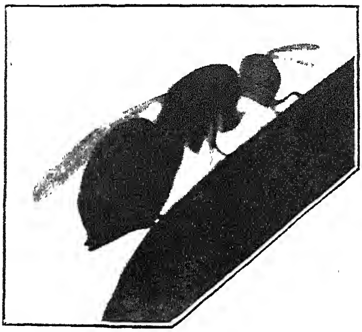
6. **Hemilexomyia abrupta** Dodd.

This Diapriid wasp was first described and figured by W. W. and J. L. Froggatt (1917, pp. 32-33) as being bred from a blowfly (? *Ophyra nigra*), and from *Musca domestica* (1918, p. 18) near Hay, N.S.W. It was more fully described and named by Dodd (1920, p. 421) under the above designation. The latter author reported it as a parasite of *Ophyra nigra* and *Calliphora villosa* (i.e. *Neopollenia stygia*) in N.S.W. (Froggatt collection). It has not been found in Brisbane.

7. **Chalcis calliphoræ** Froggatt.[2]

This fairly large insect was described by Froggatt (1916, p. 506; 1917, p. 30) from Hay district, N.S.W., as a black wasp about the size of a small housefly, with reddish-yellow antennæ, oval shining red-brown abdomen, and with thickened hind femora. This chalcid, which breeds readily in captivity, attacks blowfly larvæ and does not prevent their pupation before destruction occurs.

[2] D. Miller (N. Z. Jour. Agric., 22 June, 1921) states that large numbers of this parasite, obtained from Australia, were liberated in New Zealand two years ago, but that no definite results have yet been attained.



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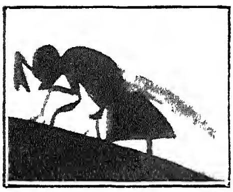

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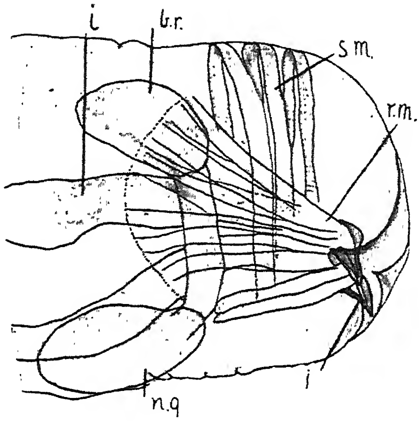

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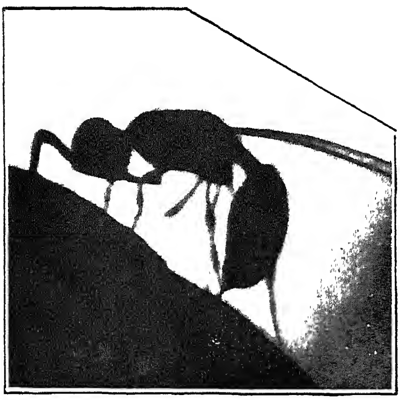

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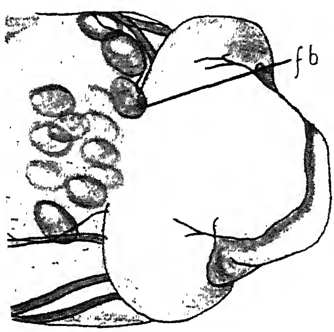

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Figs. 5-7, stages in oviposition (*Nasonia brevicornis*). 5, commencement of insertion of ovipositor ; 6, ovipositor fully inserted ; 7, oviposition completed, wasp licking up fluid from puncture ; 8, *Paraspilomicrus* ovipositing in pupa ; 9, head of larva of *Austr. giraulti*, showing suctorial apparatus, etc. (*s.m.*, sphincter muscle ; *r.m.*, retractor musculature ; *i.*, intestine ; *br.*, brain ; *n.g.*, first nerve ganglion ; *j.*, jaw) ; 10, head of larva of *Dirhinus sarcophagæ* (*f.b.*, fat body).

8. **Chalcis dipterophaga** Girault and Dodd.

Syn.: *C. calliphoræ* Johnston 1921 (from Brisbane).

This rather large wasp, which seems to differ from *C. calliphoræ* only in the lighter colouration of the antennæ and abdomen, was found on one occasion in Brisbane to be attracted to blowfly maggots. There is little doubt that the species is a parasite of the latter. Girault (1915) reported that this Chalcid was bred from dipterous puparia in North Queensland.

9. **Australencyrtus giraulti** Johnston and Tiegs.

(Figs. 1, 9, 11-17, 25-26.)

This Encyrtid wasp, of which a description is given at the end of the paper, was first discovered attacking sheepfly maggots in Brisbane in October, 1920. It was soon found that it could be bred with comparative ease and in large numbers. On one occasion many thousand individuals were obtained after several generations from a single female. During February, 1921, the wasp was again seen in the open, while during April it was quite common around decaying meat. A few specimens were seen during July, 1921.

The female attacks all the common sheep blowflies in their larval state, seeming to prefer smooth maggots (*Chrysomyia dux*, *Lucilia* spp., *Paracalliphora augur*), but will quite readily attack the "hairy" *Pycnosoma* larvæ (*P. rufifacies* and *P. varipes*) as well as those of the thick-skinned *Sarcophaga* spp. The wasps are exceedingly active, especially the females, which settle on any part of the maggots (fig. 1), and immediately begin to oviposit after showing great dexterity in clinging to the maggot as the latter crawls or wriggles. As a rule they do not appear to hurt the maggot in any way during the operation, though sometimes the latter is seen to writhe a little, no doubt when the ovipositor happens to injure a nerve.

Under artificial conditions numerous wasps commonly attack a maggot at once. When some decaying meat is exposed these wasps can often be seen close to the living maggots, and they will even attempt to parasitize those which are wriggling about immediately beneath the soil. Oviposition lasts from a quarter to half a minute, but at times when the maggot is quiet it will take considerably longer. Usually about seven eggs appear to be laid at each act of oviposition. Sometimes as many as twenty-nine wasps emerge from a pupa (artificially infected, probably by several wasps), the insects

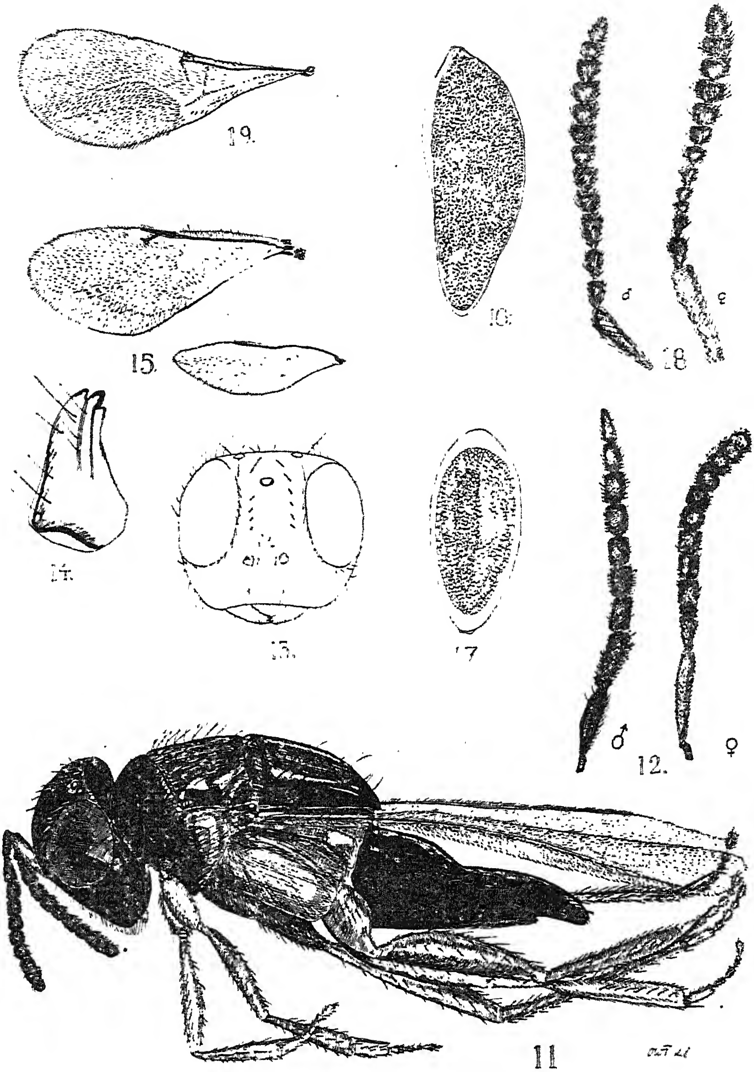
being then considerably smaller than usual. If pupæ be too heavily parasitized, then neither wasps nor flies emerge. The following numbers were obtained from six artificially infected fly-pupæ, kept under observation: 29, 26, 22, 14, 11, 10.

The freshly laid egg is rather long and somewhat irregularly shaped, measuring ·208 mm. in length and ·076 mm. in breadth. A small clear area can be seen at one end of the otherwise granular protoplasm; and it is here that the egg membrane possesses a micropyle (fig. 16). The egg soon begins to segment by the usual peripheral segmentation method characteristic of insects. After 24 hours it is in a high state of segmentation and the developing embryo can be seen in the middle (fig. 17). The egg has by this time contracted considerably, measuring only ·164 mm. in length by ·072 mm. in breadth. Hatching appears to take place in about 48 hours, but this statement is made with considerable reserve.

The larva is of the usual 14-segmented type, the nine spiracles together with the tracheæ being very evident (fig. 25). Feeding appears to take place much in the same way as in *Nasonia*, that is, by a suctorial action produced by the alternate action of protrusive (sphincter) and retractile buccal muscles (fig. 9). A pair of chitinous jaws, resembling those of the third instar of *Nasonia*, are present. The midgut does not communicate with the rectum until the end of the feeding stage, when, probably after a period of resting, defæcation takes place, and then after about one day the larva moults and a pupa appears (fig. 26).

The pupa is at first white in colour; after a few days the eyes redden and then the whole pupa darkens and gradually develops into the adult. The full period, from oviposition to emergence of the adult, occupies about 20 days in midsummer. In October it was found to be 25 days, in February 21, in May as much as 28 or even 30 days, the time gradually lengthening between February and May as the weather became cooler. In June and July it occupied approximately six weeks.

It was found that when wasps which had just emerged from the fly-pupa were isolated they would parasitize maggots as usual, and further that the offspring consisted of males and females in the normal proportion, which we have ascertained to be about 3 : 7. It must, therefore, be inferred that



Figs. 11-17, *Australencyrtus giraulti*. 11, adult female ; 12, antennæ of male and female ; 13, head, face-view ; 14, mandible ; 15, wings of female ; 16, freshly deposited egg, taken from larva of *Sarcophaga* ; 17, egg 24 hours old.

Figs. 18, 19, *Paraspilomicrus froggatti*. 18, antennæ of male and female ; 19, fore wing.

fertilisation actually took place before the wasps had emerged from the fly puparium. If this method alone took place in nature then the only opportunity for true interbreeding instead of inbreeding would occur when two females chanced to parasitize the same maggot. Copulation has been observed to take place immediately after emergence, the act occupying about a quarter of a minute.

The wasp is an exceedingly active little creature, and is easily distinguished from *Nasonia* by the brown colour of the under side, as well as by its much greater activity often manifested by leaping movements. It does not appear to live very well in close captivity, where our method adopted in keeping them has been merely to place them in glass tubes and provide them with a little diluted honey. Under these conditions they began to die on about the third day, and we have not kept them alive longer than seven days.

B.—THE ECONOMIC SIGNIFICANCE OF THESE CHALCID PARASITES.

The extent to which a species of parasite is capable of destroying or checking the numbers of its host species depends on numerous factors, all of which must be taken into account, yet which it is often exceedingly difficult to estimate, even roughly. These factors, in the case of the parasites of Australian sheep-flies, are very complex.

The most important of these factors is the accessibility of the host species to the parasite. If the parasite has relatively little opportunity of access, it cannot do much harm to the species as a whole. It may destroy large numbers of specimens of its host species, but the really important question, from an economic standpoint, is the ratio of the number destroyed to the number not available for attack. The relative importance of this factor will depend, therefore, partly on the habits of the host species and partly on that of the parasite. Unfortunately these habits are but scantily known at present.

A second important factor will be the capacity of the parasite for inhabiting a certain locality in sufficient numbers. This will depend partly on the presence or absence of necessary food or of enemies, and partly on climatic conditions.

A third important factor, and one which it is impossible to estimate in the laboratory, may be stated as follows :—Given

that a parasite will readily attack its host under laboratory conditions, will it do so on an extended scale where its host is accessible in large numbers? For example, *Australencyrtus giraulti* will attack maggots with great avidity in the laboratory, but it is not known whether it would do so if given the same opportunity on a large scale in nature. The only way to test this would be to liberate the parasite in numbers in a given district and see if it would establish itself.

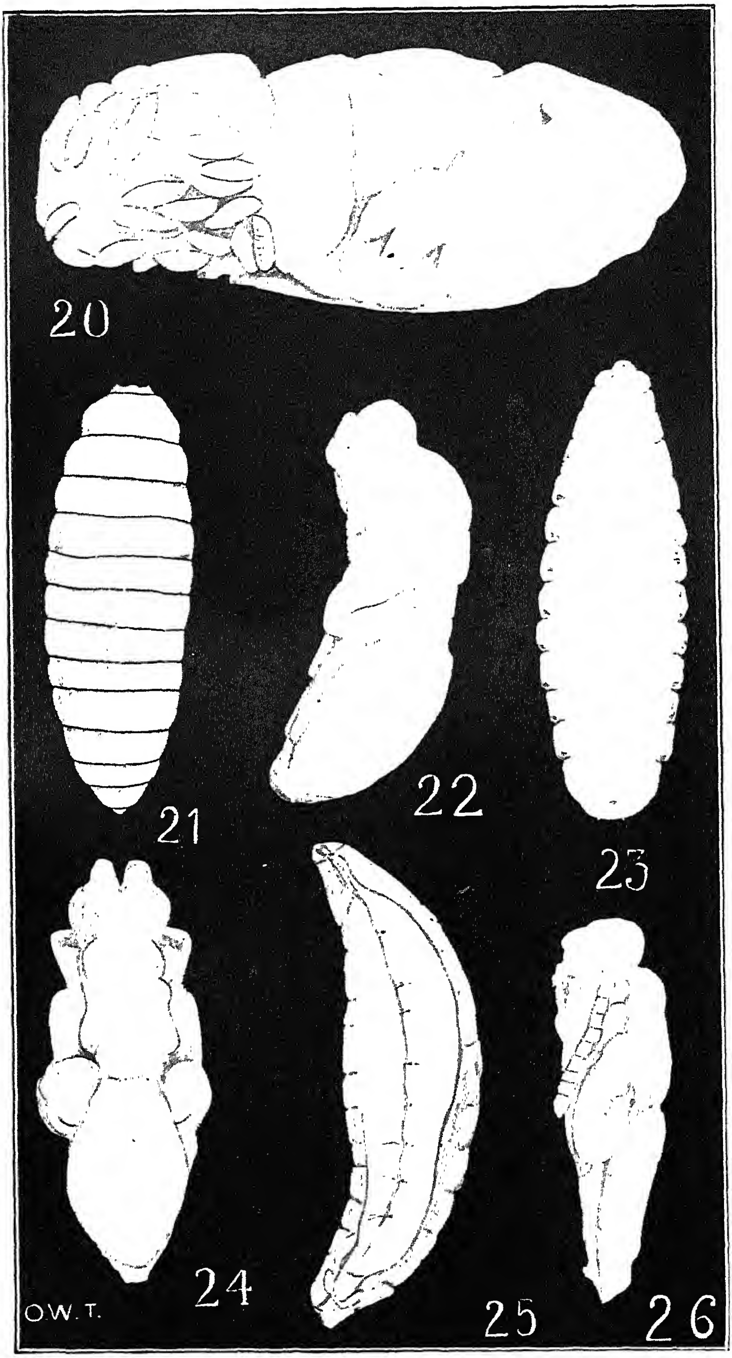
If any one of the factors be continuously unfavourable, then the parasite cannot be of any very great importance. If finally the parasite is to eradicate the host, not only would all these conditions have to be very favourable, but a fourth factor would have to be taken into account, i.e. the relative rate of breeding of host species and parasites. It will now be necessary to examine the effect of chalcid wasps on sheep-flies along these lines.

An immense amount of material for parasitizing is constantly available to these wasps: it follows, obviously, that any parasite which is not common can destroy only a very small percentage of the available larvæ or pupæ; if the available material, however great in amount, is small compared with what is not available, the economic importance of the parasite is practically nil. It seems, as will be shown below, that such is the case with those wasps which attack the fly-pupæ; and such forms as *Dirhinus sarcophagæ*, *Hemilexomyia abrupta*, *Pachycrepoideus dubius*, and *Paraspilomicrus froggatti* must be regarded as nothing more than entomologically interesting. Their scarcity probably depends on the unfavourable nature of the third factor, possibly also on the presence of enemies, or on poor food supply.

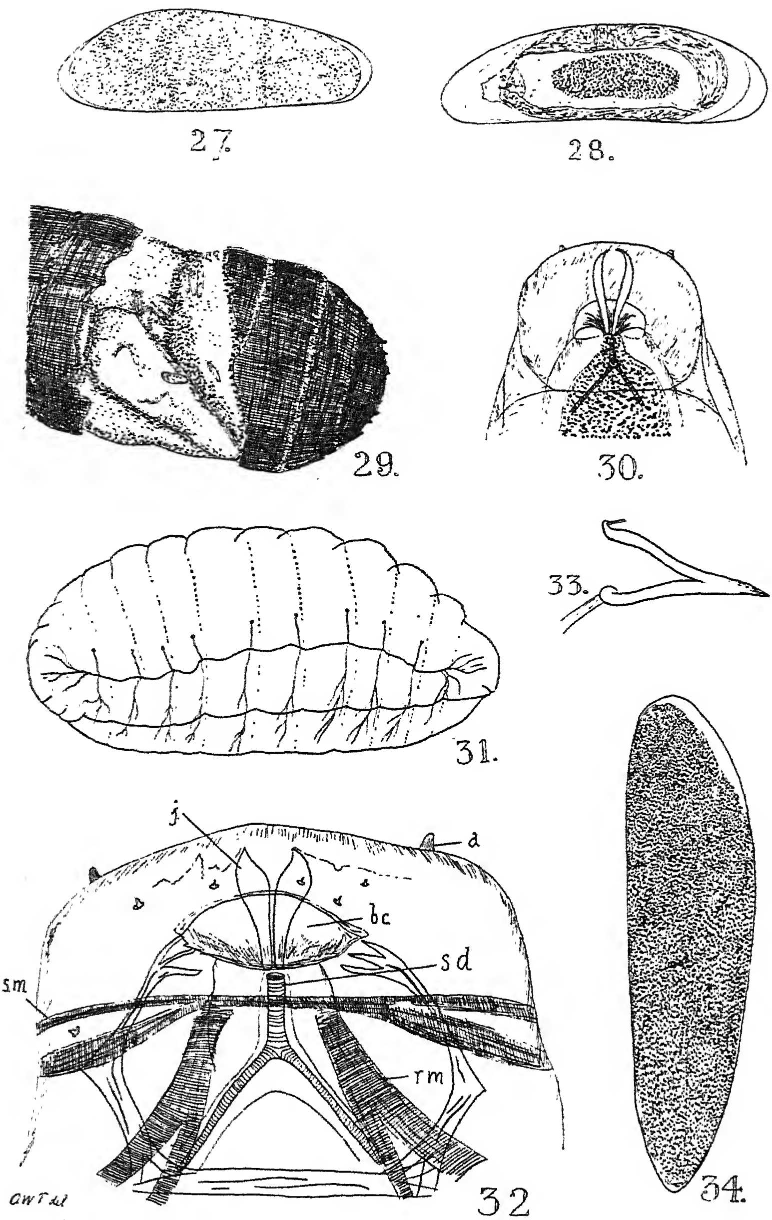
Spalangia muscidarum has been recorded as parasitizing various Muscid flies to a great extent in Eidsvold; it was also occasionally found destroying blowflies in Roma and in Brisbane, but there is as yet no evidence to show that it is of any more practical use against the sheep maggot-fly pest than such a form as *Dirhinus sarcophagæ*.

Of *Nasonia brevicornis* much has been hoped; by some it has been regarded as the ultimate means of actually eradicating, or at any rate controlling, the blowfly. Taking into consideration the above general remarks, it will be seen that these claims are founded on no very firm evidence. Even

assuming that all the other factors are favourable (which is, however, not the case) it is evident that *Nasonia* cannot possibly act as an efficient control, since the blowflies breed not only faster but also more numerously. Suppose, for example, we liberated a single female *Nasonia* and a single gravid female blowfly, e.g. *Pycnosoma*, in a certain district in which neither occurred. The blowfly would lay about 250 eggs, all of which, it may be assumed, would possibly produce adults. Now *Nasonia* would parasitize these pupæ to such an extent that about 113 offspring would be produced by it—not at the expense of 113 blowflies however, but of only about 17 to 20, as already mentioned. *Nasonia*, in fact, would be a much more useful insect if it laid only one egg per pupa. Hence after the very first generation we would have 113 chalcids and about 230 blowflies; after the next few generations the difference would become very great, and if the flies had no other enemies they would soon overrun the country. Even if we contrast the period (*a*) which elapses between the deposition of eggs by the chalcid and oviposition by the females which emerge from such eggs (oviposition occurring within a few hours after emergence), with (*b*) that occupied by *Pycnosoma* from its deposition as an egg until the resulting female is capable of ovipositing, it appears that the above result will not be materially affected; since (*a*) the wasp period referred to, during midsummer in Brisbane, is about 14 days, whereas (*b*) in the case of the blowfly it is from 14 to 16 days distributed as follows—about 9 to 10 days in the immature stages (egg, larva, and pupa) and about 5 to 6 days after emergence before egg-laying takes place. As an effective control, then, *Nasonia* is of little value. To what extent, then, does it act as a check? This depends entirely upon the ratio of the number of pupæ to which it has access, to the number of those which it cannot harm. Simple experiments, such as enclosing a number of these chalcids in a jar in the bottom of which was a thin layer of soil containing pupæ, showed definitely that the wasps would not dig into the ground, It is necessary, therefore, to inquire as to the proportion of pupæ lying on the soil to those below it. The following simple experiments were carried out during the summer of 1920-21 in Brisbane, but it should be carefully noted that they were performed partly under laboratory conditions and partly under natural *local* conditions, but not under sheep-district conditions. It is reasonable to assume, therefore, that similar



Figs. 20-22, *Nasonia brevicornis.* 20, blowfly nymph (*Lucilia*) showing clusters of *Nasonia* larvæ two days old; 21, larva in "grey stage"; 22, pupa.—Figs. 23, 24, *Dirhinus sarcophagæ.* 23, larva, seven days old, ventral view; 24, pupa, dorsal view.—Figs. 25, 26, *Australencyrtus giraulti.* 25, larva, lateral view, showing respiratory system;



Figs. 27-33, *Nasonia brevicornis.* 27, freshly deposited egg; 28. 18-hour embryo—note head, intestine, and anus; 29, blowfly pupa with a cluster of *Nasonia* eggs; 30, head-end of larva in first instar, ventral view showing jaws; 31, larva, three days after its deposition as an egg, second instar, showing respiratory system; 32, head of larva figured in fig. 31, showing jaws (*j*), antennæ (*a*), buccal cavity (*b.c.*), salivary duct (*s.d.*), sphincter muscle (*s.m.*), and retractor muscle (*r.m.*); 33, jaw of larva in third instar.—Fig. 34, egg of *Dirhinus sarcophagæ* from uterus of parent.

results will not necessarily be obtained in our Western areas as in Brisbane. It might be expected, for example, that maggots would pupate to a much larger extent in the wool, and beneath the carcass of a dead sheep (where they would be accessible to the chalcid), than they would in less protected places, such as under a piece of dry meat.[1] Experiments carried out with rather large surfaces, such as sheep's heads split down the centre to produce greater areas for protection, indicate that this does not make much difference. In view of the unfavourable results to be described, obtained locally with *Nasonia*, it seems at least worth while to repeat the experiments with various species of larvæ under sheep-country conditions during different portions of the year.

In January, 1921 (i.e. during the hottest part of the year), *Lucilia sericata* and *Sarcophaga* spp. were allowed to infect meat placed on dry soil. The experiment was carried out in the shade. After the maggots had ceased feeding the meat had to a great extent disappeared, only the fibrous portion remaining and producing an excellent shelter for pupating maggots. Different layers of the underlying soil were then removed and the pupæ in each layer counted, the following results being obtained :—

——	*L. sericata.*	*Sarcophaga* spp.
Number of pupæ—		
On surface or partly exposed ..	105	2
To depth of ¾ in.	663	14
From ¾ to 2¾ in.	1,403	47
From 2¾ to 3½ in.	172	4
From 3½ to 5 in.	51	..
From 5 to 6 in.	7	..
Percentage on surface	4·37	3

[1] J. L. Froggatt (1919, p. 260) has stated that it is generally amongst the pupæ of *P. rufifacies* and to a less extent *P. varipes* that *Nasonia* is actually found to work in the field, this being due largely to the habits of the larvæ of these particular species, which usually pupate under the edge of the carcass remains or on the bones, wool, etc., instead of crawling away as the maggots of other blowflies do.

During February a sheep's head, split down the middle, was put into a box of dry soil, and infested entirely with *Pycnosoma rufifacies* and *P. varipes.* After about six days, the head was lifted and about 100 blowfly pupæ counted: as the experiment was intended for other purposes (as described below) the pupæ beneath the soil were not counted, but it is significant that after several days thousands of Pycnosomas hatched, the bottom of a box, 2 ft. by 1½ ft., being literally green with them.

In April results were obtained which seem to show the effect of heavy rain on pupation. The sheep's heads were placed in a box, and became duly infested with *Ophyra nigra*, *Sarcophaga* spp., *Pycnosoma rufifacies*, and *Lucilia sericata*. Heavy rain fell, the whole contents of the box becoming thoroughly wet. One portion of the box was more wet than the remainder; it contained no pupæ. No pupæ occurred on the surface anywhere in the box, but were all found at a depth of from ¾ to 1 inch below the surface where the soil was least wet. Below this the soil was wetter, and only six pupæ were discovered in it, but in the relatively drier region above this level several hundred were counted. As several thousand pupæ had been expected a search was made in the soil surrounding the box, and as a result great accumulations of pupæ of all the species were found *buried in the soil to the depth of one inch* under sheltering boards close beside the box. Unprotected soil to a distance of 5 feet from the box was examined and showed the presence of numerous fly-pupæ. It would seem, therefore, that during rainy weather the conditions for *Nasonia* are even more unfavourable, since, though the maggots do not bury themselves so far down in the soil, *none pupate on the surface*. If these experiments are confirmed under sheep-country conditions, then this chalcid cannot be regarded as even a serious check on the spread of sheep blowflies.

These experiments do not take account of another serious deficiency on the part of *Nasonia*, viz., the alleged inactivity of the parasite at the very time that the flies are at their worst (Report of Blowfly Committee, Institute of Science and Industry, December, 1920).[2] Possibly this is accounted for by

[2] As this pamphlet is not readily available to workers, we deem it advisable to republish the statements relating to the work of *Nasonia* at Mr. W. Russell's sheep station, Dalmally, near Roma, Queensland :—"As occasionally over 80 per cent. of the blowfly pupæ are found to be

the following facts :—Increased fly activity generally means a decrease in the length of the life-cycle (especially the immature stages, owing to favourable conditions of temperature and moisture) and incidentally of the pupal period. For *Pycnosoma rufifacies* and *P. varipes* this latter period is $4\frac{1}{2}$ days during the summer months, becoming as low as 3 days (on an average 4 days) during the most favourable weather (February).[3] The egg period of *Nasonia* in Brisbane during this time is 40 hours. It follows that, of these 3 or 4 days which the fly passes in the pupal stage and during which the chalcid can act against the fly, nearly two days are occupied in the hatching of the parasite's egg. Hence, unless the pupæ are attacked within 24 to 30 hours after pupation, they are practically safe from destruction by *Nasonia*; indeed, we have the paradoxical conception of the pupæ of *Pycnosoma*, during this period, acting as a most efficient chalcid-destroyer—in other words, as a "Nasonia-trap," in that at least half the chalcid eggs deposited must be wasted, unless, of course, the wasp will instinctively refuse to oviposit in advanced pupæ.[4] The immunity of *Pycnosoma* to *Nasonia* attack was exhibited by the following experiment, carried out in February, 1921, when *Pycnosoma* spp. are the dominating blowflies in Brisbane. A split sheep's head was placed in a box of soil and allowed to

killed by this parasite, it should have a marked effect in controlling the increase of the flies, but unfortunately the Chalcid Wasp seems to be dormant at the very time the flies are worst. Very much has yet to be learned of the life-history of both flies and parasites. This tends to show that although it must be a check, yet it cannot in the light of present knowledge be classed as an overwhelming check. At Dalmally, in the height of the attack of the present year, Chalcids were not to be found. Then at the end of September they began to show in the breeding cages and are now (December, 1920) breeding in big numbers. Even if the Chalcids be responsible for the abatement of the fly trouble since October, it was quiescent when the principal losses in sheep occurred. We conclude therefore that while Chalcids are certainly a check, they are not, in the light of our present knowledge, important enough to supersede the jetting process."

[3] J. F. Illingworth in an article, "The Australian Sheep Fly in Hawaii" (Proc. Ent. Soc. Hawaii, 1917 (1918), 3, p. 429 ; Abstr. in Rev. Appl. Ent., B., 6, p. 163) referred to the rapid development there during July. A dead animal was exposed on 16th July, larvæ hatched out next morning, and three days later entered the soil to pupate, the pupal stage occupying about six days.

[4] Altson (1920, p. 224) states that *Nasonia* shows preference for pupæ between 24 and 72 hours old for oviposition. We have found that the wasp will readily oviposit in living blowfly pupæ of any age.

become heavily infested with these two species. When the maggots had begun to pupate the box was closed by a "wasp-proof" gauze, and 250 Nasonias liberated in the box. The wasps could perhaps scarcely have had a better opportunity for demonstrating their action on pupæ buried in the soil, as well as on recently pupated *Pycnosoma* pupæ. As stated above, about a hundred pupæ were found beneath the sheep's head, but the result of the experiment showed that several thousand had entered the soil. Pycnosomas hatched in due course in immense numbers. Thirteen days later *twelve Nasonias hatched*, probably all from one unfortunate pupa! Here, under the best conditions, except that they were in captivity (which does not seem to make much difference with *Nasonia*), the wasps were helpless in the face of a reduced pupal period on the part of their host-fly. It is at least possible that these facts will account for the field observations above quoted.

If these laboratory experiments can be confirmed in the field, it is evident that little can be hoped from such wasps as oviposit in pupæ. Parasites which attack the larvæ should be much more useful, since they can obtain access to all the individuals that the former class can, as well as many that the former cannot. To this group belong *Chalcis* spp. and *Australencyrtus giraulti*. The former can probably be dismissed on account of their rarity, though of course they might be bred up in the laboratory. The latter is more hopeful, as it appears to be fairly common in Brisbane and breeds very easily, but has, unfortunately, a rather long developmental period. The first factor, namely, access to its host, is very favourable; of the others, however, nothing is known, and it might turn out quite useless in the field. We hope to distribute a large number later in the year in the hope that this Encyrtid may be of some use.

To this latter group of maggot attackers belongs also an English Braconid species, *Alysia manducator*. This has all the advantages possessed by the above-mentioned maggot-parasitizing wasps, and has also the additional qualification of laying a very large number of eggs and distributing them among an equal number of maggots. A wasp living under English conditions might be unable to exist in the Australian climate; but, on the other hand, it might be stimulated to greater activity, and it is certainly a parasite well worth

attempting to introduce into Australia provided that it is not already known to parasitize useful insects (Graham-Smith, 1916, 1919; Johnston and Bancroft, 1920; Altson, 1920).

Table showing Parasites and Hosts in Australia.

The following table may be of interest. It is not unlikely that all the parasites mentioned may prove to be able to attack all the species of flies in the list. The introduced English blowfly, *Calliphora erythrocephala*, does not occur in Queensland as far as we are aware, though Froggatt has reported its presence in Sydney.

Australian Muscoid Flies.	PARASITES.							
	Nasonia brevicornis.	*Paraspilomicrus froggatti.*	*Spalangia muscidarum.*	*Dirhinus sarcophagæ.*	*Pachycrepoideus dubius.*	*Hemilexomyia abrupta.*	*Chalcis calliphoræ.*	*Australencyrtus giraulti.*
Chrysomyia rufifacies[5]	×	..	×	×	..	..	..	×
Microcalliphora varipes	×	..	×	×	..	..	..	×
Lucilia sericata	×	..	..	×	..	..	..	×
Lucilia spp.	×	×	×	×	..	..	..	..
Ophyra nigra	×	..	..	..	..	×	..	..
Chrysomyia dux	..	..	×	..	..	..	..	×
Paracalliphora augur	×	..	×	..	..	..	×	..
Pollenia stygia	×	..	×	..	..	×	..	..
Calliphora erythrocephala ..	×	..	..	..	..	..	..	..
Sarcophaga irrequieta	×	..	×	×	..	..	..	
Sarcophaga aurifrons	×	..	×	×	..	..	..	.
Sarcophaga misera	×	..	×	..	..	..	..	..
Sarcophaga impatiens	×	..	×	×	..	..	..	..
Sarcophaga spp.	×	..	×	×	..	..	..	×
Musca domestica	×	..	×	..	?	×	..	..
Musca spp.	×	..	×	..	..	..	..	..
Stomoxys calcitrans	..	..	×	..	..	..	..	..

C.—DESCRIPTIONS OF NEW HYMENOPTEROUS PARASITES OF AUSTRALIAN BLOWFLIES.

Australencyrtus giraulti n. gen., n. sp. (Encyrtidæ).

(Figs. 1, 9, 11-17, 25, 26.)

Description of Female.

Length of moderate-sized specimens 1·6 to 1·92 mm. Small individuals may be much shorter, measuring little over

[5] The first two species are referred to in the rest of this paper under the genus *Pycnosoma* as they are generally known by such name in Australia. According to a recent remark by Mr. W. W. Froggatt, the correct name for *C. rufifacies* is *C. albiceps* Wied. (P.L.S., N.S.W., 1920, p. 472).

1·2 mm. in length. All measurements given below refer to a large form 1·8 mm. long. The wasp is easily recognised by its shiny-black upper surface and pale-brown under surface (figs. 1, 11).

Head (fig. 13).—Height ·6 mm.: breadth ·5 mm.: length ·32 mm. Depth of eyes about half that of head. Distance of ventral portion of eyes to mouth twice that of dorsal part to vertex. Head shiny black with very faint reticulate pattern: the numerous bristles generally lodged in small depressions. Ocelli large and prominent, nearer to eyes than to one another. Frons with a deep depression. Clypeus gently convex. Insertion of antennæ on a level with lowest part of eyes, their distance from one another equal to their distance from the eyes.

Eyes bare: about fourteen bristles immediately around orbit; two vertical bristles in line with posterior ocelli. Front with about fifty other bristles.

Mandibles shiny black, long (·216 mm.) and prominent, tridentate, the anterior tooth very small: the middle one larger and prominent, the lowest somewhat smaller: all very obtuse (fig. 14). Mandibles provided with twelve bristles. Maxilla short, foliaceous, covered with about twenty hairs on upper surface. Palps pale brown, long and prominent, last joint especially large. Submentum not prominent; the mentum somewhat triangular and provided with a row of short bristles. Labial palps rather small, with three joints of which the second is the smallest. Mentum with prominent but short ridges.

Length of antennæ ·88 mm.; maximum breadth ·06 mm. Ten joints including ring-joint. Scape slender, about ·25 mm. in length, slightly broader at tip than at base, moderately bristly, brown. Pedicel about one-third length of scape, very conical. Ring-joint very indistinct, about ·02 mm. long. The following six joints very dark brown and heavily clad with short bristles; the proximal one oval, the others gradually shortening, the most distal dome-shaped. Club 3-jointed, ·16 mm. in length (fig. 12).

"*Thorax*."—Shiny black above, light brown below; pronotum prominent, length about half that of head; with delicate transverse striations. Mesothorax about thrice the length of pronotum; as the anterior part of the pronotum projects into the posterior concavity of head, and also is longer at the sides than dorsally, the mesothorax appears, in dorsal

view, nearly six times the length of the pronotum. Scutellum very prominent, about two-thirds the length of scutum. Scutum distinctly ridged; pronotum faintly striated; scutellum smooth. In the middle of the scutellum on either side of the mid-line, the chitinous plate has a pair of small circular holes. The ventral side of thorax light brown, shiny. From the postero-ventral region of the pronotum a thin plate, pale brown in colour and rather transparent, is given off backwardly, reaching so far back as to overlap the tegulæ ventrally. Probably the anterior spiracle lies beneath this plate; a similar structure is developed along the whole of the ventral portion of the mesonotum, and overlaps a portion of the last coxa; it is light brown in colour, much stronger than the similar extension from the pronotum, and appears to be hollow. The second spiracle is probably hidden beneath this structure. From the metathorax a similar overlapping structure is developed, but it is much smaller. Immediately behind it lies the third spiracle: just above it is a small cluster of silvery hairs. Pronotum with a row of 18 short (9 and 9), scutum with 56 (28-28) rather long bristles; scutellum with 22 (11-11) moderately long bristles on anterior half, a pair on the border, three-quarters the distance to distal end, and a pair of rather long scutellar apicals. Tegulæ each with three bristles.

Legs brown.—First leg: Coxa largest, powerful; breadth half the length: thirteen bristles externally, and two rows of small bristles on posterior (inner) margin. Trochanter half the length of coxa: double-jointed; hairless. Femur rather short, twice the length of coxa and thick-set; with four rows of moderately long bristles. Tibia one and a half times the length of coxa, slightly broader distally than proximally; spur as long as that of second leg, but considerably weaker, with five rows of moderately long bristles. Tarsus nearly as long as femur, the five joints very hairy; claws not markedly large.—Second leg: Coxa longer but less stout than in first leg; provided with six longitudinal rows of bristles. Trochanter long, double-jointed, hairless. Femur as long as first femur, but rather weaker; with six longitudinal rows of bristles. Tibia long (·56 mm.), thinner than femur; with five rows of bristles, the enlarged tibial spur very faintly serrated at its inner distal end. First tarsal joint much elongated; claws small.—Third leg: Coxa exceedingly stout, a little longer than broad, with a faint reticulation; six rows of short bristles.

Trochanter single-jointed and with five rows of bristles. Femur about as long as first, but bulging strongly in middle, with six rows of bristles. Tibia a little shorter than second; bristly; first tibial joint much elongated, claws small.

Wings (*fig. 15*).—Fore wings: Length 1·44 mm., breadth ·77 mm. Submarginal : marginal : post-marginal : stigmal = 37 : 5 : 6 : 8. Length of submarginal ·59 mm. Submarginal with fourteen large bristles, those in middle of vein the largest. Marginal and post-marginal with three rows of rather shorter bristles. Stigmal with eight bristles: its termination broadened, angular, hooked and bluntly pointed, 4-punctate as figured. Anterior border strongly ciliated. Whole wing ciliated, except posterior border and a small area anterior to this.—Hind wings: Length ·96 mm., breadth ·32 mm. The distal marginal part of the wing-vein ·3 mm. long; the distal submarginal portion very slightly longer and rather transparent, and with two punctures. A row of eleven bristles immediately anterior to it. Wing ciliated, except for a clear area at base of wing.

Abdomen shining black, marked with a delicate reticulum. Rather broader than thorax, and dorsoventrally compressed. First tergite as long as the next two together. Second, third, and fourth tergites all about equal in length. Fifth rather longer, and partly overlapping the more anterior ones, being very concave in dorsal view. First tergite with five pairs of bristles laterally; sternum with very numerous short bristles, and three pairs of longer bristles posteriorly. Second tergite with a transverse row of seven moderately large bristles on either side; five pairs on sternum. Third tergite with a transverse row of seven bristles on either side and a very long bristle laterally; three pairs on sternum. Fourth tergite with a row of six bristles on either side; sternum with a group of eight pairs. The fifth tergite very bristly; anteriorly a row of four bristles on either side; posterior to these a row of five larger bristles; a marginal row of twelve bristles on either side; the most anterior part of the tergite with a small rounded thickened chitinous area bearing five large bristles. Sternum with five pairs of bristles. The termination of the ovipositor provided with a marginal row of ten bristles. Point of ovipositor sharp; no serrations present; length ·45 mm.; free posterior part of sheath ·16 mm.

Description of Male.

The male closely resembles the female in general appearance and size. It differs in the following characters :—

Length of antenna (fig. 12) greater, being about 1·2 mm. ; scape very slightly shorter than in female, measuring about ·24 mm. in length ; next joint, corresponding to the pedicel, very short, ·08 mm. in length ; third joint ·16 mm. in length. The following seven joints about equal in length, measuring ·096 mm. ; the most distal joint not club-shaped, but somewhat conical with apex of cone distally, without any sign of division into three parts such as occurs in female. Length of mandibles about the same as in female ; teeth slightly more acute.

Thorax as in female. First coxa shaped as in female ; seven large marginal bristles, ten smaller externally, numerous minute bristles internally. Trochanter single-jointed, two bristles on dorsal distal end. Femur with three rows of bristles, and an indication of a fourth row. Second trochanter very short, single-jointed, hairless. Bristles of second femur weak. Tibial spur weaker than in female.

Wings as in female, except that the stigmal vein is very slightly shorter, the termination a little more hammer-shaped. Size exactly as in female.

The third abdominal segment bears ventro-laterally a very long bristle, even longer than in female. The penis is rather long, about equal in length to the terminal part of the ovipositor of female.

The biology of this little wasp has been described in an earlier part of this paper, the various immature stages being figured (figs. 9, 16, 17, 25, 26).

Systematically the insect belongs to the Chalcidoid family Encyrtidæ, sub-family Encyrtinæ, tribe Mirini of Ashmead, or Encyrtini (as considered by Girault, 1915). It does not fall into any of the genera as given in either Ashmead's or Girault's keys. We therefore propose to establish for its reception a new genus, *Australencyrtus*, with *A. giraulti* as type. Mr. A. A. Girault, the well-known authority on chalcid wasps, informs us that it comes near Perkins's genus *Echthrogonartopus*. It differs from that genus, however, chiefly in that the club is distinctly shorter than the funicle ; the frontal region between

the eyes is considerably wider than the width of eyes, and the scutellum is not sculptured: while the post-marginal vein is very slightly shorter than stigmal.

Type specimens (allotype and holotype) deposited in the Queensland Museum, Brisbane. Bred from various blowfly pupæ in Brisbane.

Paraspilomicrus froggatti n. gen., n. sp. (Proctotrypoidea—Family Diapriidæ). (Figs. 4, 8, 18, 19.)

Description of Male.

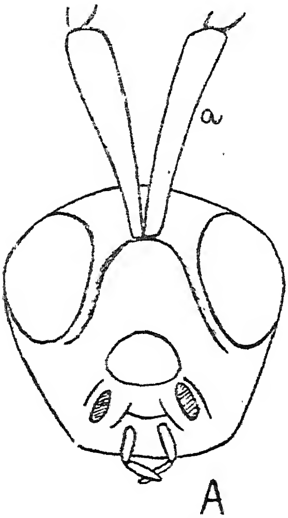
Length 1·7 mm. (excluding antennæ): shining black.

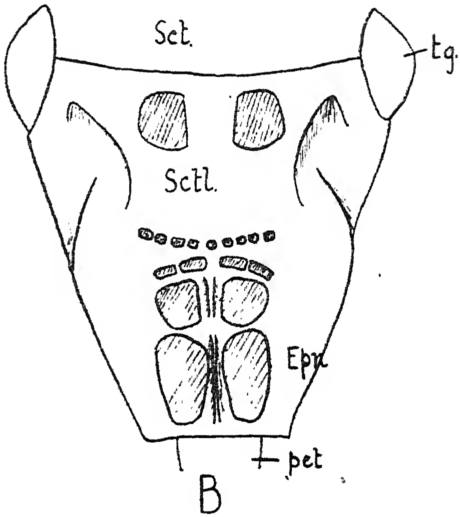
Head.—Length ·34 mm.; height ·45 mm.: breadth ·37 mm. Frons not protruding in front of eye. Eye rather small, bare, distant its own height from mouth; depth less than half the height of head. Ocelli very prominent, as near to each other as to eyes. Head smooth, shiny black, without pattern, with numerous short bristles. Antennæ (fig. 18) inserted on a marked prominence: very long (1·15 mm.), consisting of thirteen joints: scape ·32 mm. long: pedicel and next two joints about equal (·08 mm.): remaining joints shorter, broader, and rounded, last elongated and conical, the whole covered with numerous rather short bristles. Palps long, brown, terminal segments slightly longer than sub-terminal; both bearing six setæ.

Thorax.—Length two and a half times the breadth. Tegulæ very prominent, forming large angular prominences at sides. Pronotal neck short, with longitudinal shallow excavations; pronotum itself hardly visible from above. Scutum smooth, shiny black, without any pattern; parapsidal furrows very prominent; rather wider than long; with a small number of moderately long, brown reclinate bristles, developing into a more pronounced growth laterally just behind pronotum. Scutellum four-fifths length of scutum, with a light growth of hairs; a pair of large square depressions on either side of mid-line, just behind scutum; and a transverse row of nine small rounded depressions crossing the scutellum two-thirds the distance from anterior end. Behind these, a row of four larger rectangular depressions. Epinotum with a complete median longitudinal carina; with four irregular ridged depressions laterally. Petiole with a complete median carina and two pairs of longitudinal depressions on either side, more

distinct in anterior half; provided laterally with rather long, somewhat curled hairs. Epinotum sculptured laterally and with a growth of short silvery hairs. Scutum and scutellum quite bare and smooth at sides. Pronotum with a growth of hairs laterally along posterior margin. Thorax lightly hairy beneath.

Paraspilomicrus froggatti.





Text-fig. A, Face-view. B, Dorsal view of posterior end of thorax.

Epn., epinotum; *pet.*, petiole; *sct.*, scutum; *sctl.*, scutellum; *tg.*, tegula. Shaded portions represent depressions. Only first joint of antenna (*a*) showing in Fig. A.

Legs.—Coxæ dark brown, hairy, short and stout, especially the third. Second coxa weaker than the others. Trochanters very long and slender. Femora long, hairy; proximal half narrow, distal half expanded to become markedly club-shaped; proximal portion light brown, distal very dark brown, nearly black. First and second tibiæ rather shorter, dark brown, hairy, provided distally with two moderately long setæ; last tibia considerably longer, and with a distinct tibial spur. Tarsi five-jointed, moderately long; last very long; all hairy, but not markedly so; claws short.

Wings.—Length of fore wing (fig. 19) 1·6 mm.; breadth ·64 mm.; submarginal vein ·64 mm. long; marginal vein very thick and short, ·064 mm. long, with six long bristles;

stigmal vein very short (·024 mm.), 4-punctate, and with one long bristle. Rest of venation very poorly developed. Heavily ciliated especially posteriorly; on proximal part the ciliation is very sparse. Length of posterior wing ·96 mm.

Abdomen.—Epinotum and petiole described in connection with thorax. Rest of abdomen long and slender, about as long as thorax, with scattered hairs ventrally and post-dorsally; smooth and shiny black; termination sharply pointed.

Description of Female. (Fig. 8.)

This closely resembles the male, the most pronounced differences being in regard to the antennæ. Scape, pedicel, and next joint similar to those of male. The following two joints considerably smaller than in female, equal in size, rounded; the remaining joints gradually becoming longer and broader; terminal joint conical giving the whole antenna a slightly club-shaped appearance.

Systematic Position.—It has been considered necessary to erect for the reception of this species a new genus near *Hemilexis* Foerster, *Spilomicrus* Westwood, and *Hemilexomyia* Dodd. The name *Paraspilomicrus* is proposed.

Generic Characters.—Antennæ 13-jointed; scape unarmed; antenna in female somewhat club-shaped, last joint short and conical. Head not punctate, smooth; no ridges on temples; pronotum short; mesonotum slightly convex laterally, smooth; not ridged. Scutellum with two small prominent basal depressions, and laterally from each a larger shallow indistinct depression. Two transverse rows of small depressions towards posterior end of scutellum. Petiole about twice as long as broad; the large abdominal segment overlaps petiole dorsally, abdomen somewhat pointed, not truncate. Fore wing with pronounced submarginal vein; marginal vein thick and short, about twice as long as thick. Stigmal vein very short, punctate, rest of venation practically obsolete. Type: *Paraspilomicrus froggatti* Johnston and Tiegs, 1921.

The specific name is intended as a tribute to Mr. W. W. Froggatt, Government Entomologist of New South Wales, who has done so much to increase our knowledge of sheep maggot-fly parasites.

Bred from pupæ of *Lucilia* spp., Brisbane, November, 1920. Holotype and allotype have been deposited in the Queensland Museum, Brisbane.

SUMMARY.

In the present paper three new primary hymenopterous parasites of sheep maggot-flies are recorded,—*Spalangia muscidarum* Richardson, *Paraspilomicrus froggatti* n. gen., n. sp., and *Australencyrtus giraulti* n. gen., n. sp.—and a few observations on the life-history of these and certain others are recorded.

As a result of a short investigation regarding the habits of these wasps and their hosts, it appears likely (from laboratory experiments only, however) that the value of some of these, especially *Nasonia brevicornis*, has been greatly over-estimated.

In conclusion, reasons are given for the advisability of the introduction of the well-known English sheep-fly parasite, *Alysia manducator*.

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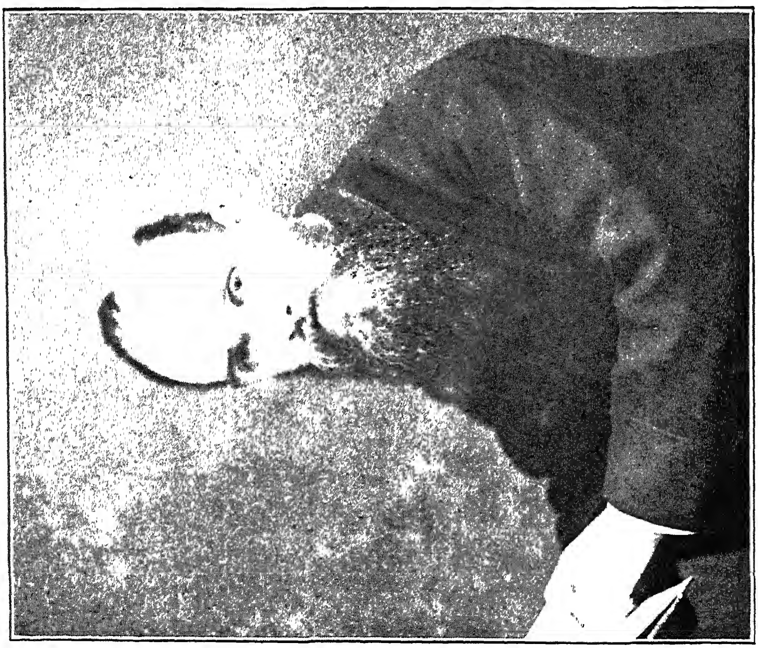


SYDNEY B. J SKERTCHLY (In 1877 and in 1921).

GLACIAL MAN:

MY PART IN HIS DISCOVERY.

By Sydney B. J. Skertchly,

Late of H. M. Geological Survey of England, Past President.

(Delivered before the Royal Society of Queensland, 27th April, 1921.)

INTRODUCTORY.

It is quite appropriate that I should address you on the subject of the Antiquity of Man. *Me voilà !*

My discovery of the remains of glacial man was no fortuitous accident, but the culmination of a long and strict training. If like my predecessor the late Mr. Jack Horner I put in my thumb and pulled out a plum, it was not that I had stumbled upon the pastry, but that I had studied the ways of the cook, and knew where she got her raw material.

My very earliest memory is a distinct vision of a joyful moment in a gravel-pit. Amid vague, dark-flitting surroundings my mind's eye still pictures a long garden, quite without detail ; but clear and bright, a beacon in the gloom, comes the remembrance and the *smell* of enchanting red-brown gravel stones that my infant fingers fondled. Always clumsy, I was constantly being picked up with abraded knee-caps and *os frontalis*: my earliest ailment was gravel-rash. I am gravel-rash still. Gravel has yielded me my choicest quarry in each of the globe's four quarters, and as the sands of life run out, to gravel I still turn unsated, for Australia's river-banks are yielding me treasures valuable as those of Europe and America, and equally despised, for, though I have been telling you about them for five years, not a single one of you has had the curiosity to take a three hours' journey to see the evidence. It may please you to know the Nerang River is sick with waiting and is rapidly erasing the writing on the wall you would not read.

About my ninth year we removed to Ashby-de-la-Zouch, famed in "Ivanhoe," near which my father was establishing

encaustic and mosaic tile-works. Here he realised my uncanny faculty for nosing out the boundaries of clay-beds. and from that time, he a man of learning and originality. fostered my peculiarity, initiating me in many a ramble into the mysteries of vegetable physiology and insect lore, training me to use the microscope, and to handle mathematical and optical instruments familiarly.

My first teacher in geology was Ralph Tate, who died not long since Professor of Geology in the University of Adelaide ; but my real teacher was Sir A. C. Ramsay, for many years afterwards my chief on the Geological Survey of England. Huxley built up my biology, and, I think, never quite forgave me for eschewing Natural History for my first love, Geology. Prof. Partridge kept my human anatomy bright. Dr. Duncan lured me with corals, and delighted me by allowing me to help name some of Darwin's corals from the "Beagle" voyage. Bates, an old family friend, had come back from the Amazons, and to his dying day never realised that I had grown up and could walk upright. Faraday used to visit my father. All my days were spent with scientists, artists, poets, and (for my sins) politicians. What a childhood it was !

But the crux of my life was my connection with the Tylor brothers, Alfred and Edward. The North London Railway had run a line through the contorted gravels of Hackney Downs. Here to my delight I found not only Mammoth bones and Urus but a rich deposit of freshwater shells. I carefully drew the section, collected and named the shells. But one puzzled me. It was a stranger, and I dared to hope it might be *Cyrena fluminalis*, not now living nearer than the Nile (where to my delight I afterwards found it) but known in a few of the older pleistocene beds of England and France. I see, in the mind's eye, a timid lad of thirteen with a box of shells, knocking quietly at a door in Paradise Row, Stoke Newington, having screwed his courage to call uninvited upon the rich Quaker geologist who lived there. I was ushered into a fascinating room, half library and half museum, and tremblingly awaited the coming of the great man. He looked at my shells and took me right into his warm heart. He was my true father in science ; his house in town and country was my second home, and afterwards my only one ; and till I dropped a few gravel pebbles on his coffin, his love and wisdom were my pride and stay. As an engineer he drilled me into

accuracy of measurements of distances, depths, and angles. A section to him was no sketch unconsciously modified to tally with hypothesis: it must be a portrait. This lesson has stayed with me. In that study, that eventful night, I saw my first palæolithic implement (exhibited). Tylor taught me to use theodolite, level, and clinometer; his books and specimens were at my disposal, and patiently he led me over all the pleistocene and recent beds of the Thames valley, and these and those of Northern France I carefully examined, levelled for him or with him. Alfred Tylor was both geologist and anthropologist, but the lustre of Sir Edward his younger brother's name has overshadowed the fame of the greater Alfred. Only in one way, save in love, could I recompense him: I dedicated my "Physical System of the Universe" to him, and, good simple soul, he used to carry a copy of it about with him and show folks the title-page; and when Darwin and Wallace wrote congratulating me he was if possible more pleased than I was. For more than two-score years the winds have sung a requiem through the oak-leaves over his grave, and I have grown old and widowed; but in dreams each night as I press my lonely pillow, two faces come to me, my sweet wife's and Alfred Tylor's, and when in the not distant years I too am but a shade I fain would that some of my friends may carry kindly memories of me, if but in dreams.

Largely through Alfred Tylor's influence I had the inestimable advantage of spending a year as Librarian and Diagram-maker at the Geological Society. Here I made the acquaintance of the great founders of Geology—Sedgwick—Phillips, Murchison, and above all of Sir Charles Lyell, the true father of modern geology, the founder of the Tertiary system, the great expounder of the action of existing forces, the inspirer of Darwin. Lyell was very good to me, and used to come, ask in his inimitably modest way if I could spare a little time for a chat! Fancy it! Spare time! I could have sat at his feet a lifetime. He used to tell me all his early struggles to drive out the perniciously convenient cataclysms and convulsions of nature that accounted so easily for cliff and gorge and contorted rock. His philosophical brain poured out to me of its vast stores, and warned me of many pitfalls, many a *cul-de-sac* in reasoning. To Lyell, next to Alfred Tylor, I am in grateful bondage still: they can never be repaid.

At the Geological Society I acquired a thorough knowledge

of the literature of geology in most of the European languages, and all the while was working hard with Huxley at biology. Never very strong, my strength began to fail, for I was working double tides, grudging every hour of sleep. So when I was offered the post, vacated by Clement (afterwards Sir Clement) le Neve Foster, of assistant geologist to Ismail Pasha, Khedive of Egypt, inclination and health caused me to accept at once, and so good-bye to all hopes of a School of Mines diploma: I did not care to grow learned by "degrees" when I could acquire knowledge in the bulk, and on Christmas Day, 1869, I landed in Alexandria with H. Bauerman as chief and John Keast Lord as naturalist.

How gladly would I here tell of the glamour of Egypt. He who quaffs the waters of Old Nilus shall long therefor for ever, said Herodotus; and it is true, for from that day to this my love of Egyptology has known no abatement. In the old-fashioned sloop-of-war "Tor" we visited every headland and bay on the Red Sea coast, from old forgotten Berenice the Roman port for their emerald mines and porphyry quarries, to beyond Bab-el-Mandeb where at Zeyla the raised coral reefs, far inland, shine like silver diadems on the dusky basalt brows of Ethiopia. We made extensive journeys inland by camel and on horseback into Nubia and Abyssinia. In Egypt I found neolithic stone implements, in Nubia stone-circles perch halfway up the mountain-side on tiny plateaus, and in some of the wadies both in Abyssinia and Arabia I found palæolithic implements that my colleagues laughed at.

In long camel-rides across the desert I had unique opportunities of studying the action of blown sand, but my glory was the Red Sea coast which I knew from end to end along the African and on many parts of the Asiatic shores. This great rift valley was to me one splendidly clear section 1,500 miles long, the story of whose rises and falls was written in white coral upon dark rock. It is one vast fold, depressed in the middle, elevated at the Suez and Somali ends, the latter being the highest part. Atoll and barrier and fringing and raised reef tell the story graphically—the raised reefs off Shadwan in the north make a white streak on the black diorites, it sinks to sea-level as you go south and the barrier reefs stretch outwards into the sea, till in the central depression the Dahlac Isles lie as atoll jewels under the burning skies. Southwards the raised reefs come on again and reach their

highest point south of Bab-el-Mandeb. It was a glorious confirmation of Lyell's views, which led to Darwin's theory and confirmed its general truth. My letters to Darwin on this quite new evidence gratified him and led to a long friendship.

Returning to Cairo Sir Samuel Baker asked me to take a branch of his Soudan expedition (*viâ* Sowakim) to Berber across the desert, as I was acquainted with some of the way and the natives knew me. This was a thing after my own heart, but family matters called me home, and my friend Higginbottom, an engineer, gladly accepted the post and, alas, died *en route*. I left Egypt with profound regret, but carried with me the memory of two grand sections, the Great Rift Valley, and the Suez Canal, then being dug, and along much of whose bed I have walked.

Returning to England I at once joined the Geological Survey, and to Ramsay's joy selected the Fenland for my field of work, as it was the most extensive area of newer rocks in the kingdom, and being supposed to be a compost of gravel, bog, and ague, no one had volunteered to survey it, nor had our good chief the temerity to order any of his men into its (reputed) wastes. Here I spent four happy years at my favourite study of recent geology, gaining a thorough acquaintance with what might be called the neolithic series. In the fens I met my first master in working flint. It was that unmitigated scamp Flint Jack, an expert whose forgeries are in every museum and well-nigh every private collection from John o'Groats to Land's End. I last saw him in Piccadilly garbed in a rusty brown coat as appropriately as a hedgehog in lace. He told me with tears how in his old age he had repented him of the evil that he had done, and was going to an honoured grave as an honest man in constant employment—making Egyptian antiquities for the trade. He was an irreclaimable rascal, but oh! he was an expert in flint.

By this time surely I was peculiarly fitted for the task that all unknown lay before me. The two Tylors and Lyell had trained and moulded my strange taste for Post-Tertiary geology; travel had widened my outlook; four years steady work in the fens had given me experience, and I was now ready for what I may perhaps not immodestly term my great work. Certainly no living being had my special training, and the difficulty of interpreting the evidence is shown by the fact that it has taken forty years for geologists and

anthropologists to reach the point I had arrived at in 1878, forty-three years ago, when I made my first announcement of my discoveries in Nature, vol. xvi, pp. 142, 163.

Having finished my Memoir of the Fens I went up to Brandon in Suffolk on its borders, a place already renowned for the palæolithic and neolithic implements its neighbourhood had yielded. It is now necessary to state briefly the condition of public and scientific opinion in those days.

PUBLIC OPINION, LAY AND SCIENTIFIC.

The mild and friendly criticism which to-day does duty for the old *ódium theologicum* is hardly generically homologous with the triumphant venomous outpourings against science in general and geology in particular that in my young days did duty for orthodoxy. Even at the social board a grim silence fell if anyone rashly uttered the word "Evolution." In 1872 I published my little Manual of Physical Geography, with which the vice-president of the Royal Geographical Society was pleased to be pleased. He was a merchant in a large way, and ordered some hundred copies to gratify Tylor and do me a good turn. But finding something about evolution at the end of it he countermanded the order. No wonder Darwin wrote to Hooker, "I begin to think every man is a fool who writes a book." You smile at this, but I didn't at the time, but to understand my position it is incumbent that you realise the atmosphere of the seventies.

In the geological world things were as follows:—The Geological Survey began its work in Cornwall and South Wales, where the pleistocene beds cover but a small area; and as nobody took much interest in them—save in the tin gravels—they were generally ignored on the maps, and all of them, sands, gravels, and clays, lumped together under the comprehensive term "Drift." Hence the implements from the gravels were called "drift implements." As the survey extended northwards these drift-beds took up greater and greater space, till by the time we were fairly among the glacial beds they occupied pretty well as much ground as those euphemistically called "solid" beds. Still we were expected to ignore them, consequently maps were issued with dotted boundaries where the solid beds ran under the drifts, till finally some of the maps showed limestones and sandstones

where no human eye could see anything but boulder-clay, save stones from the bottoms of wells. Then we field-men protested, and the mapping of the so-called superficial beds was seriously taken up. Even then two sets of maps were issued, the one showing the solid geology, the other drift maps. At last when, as in Rutland, the drift occupied 90 per cent. of the ground this ridiculous division was finally abandoned, and now all our Geological Survey maps show all the beds that appear on the surface.

Louis Agassiz had demonstrated the former existence of a glacial epoch, and we all thought the ice had come on gradually, culminated, and passed slowly away. But we who had to deal with the beds in our daily work soon found this simple, free-and-easy theory would not work. All boulder-clay was not mere iceberg droppings; most of it was the ground-moraines of land ice—of glaciers. Moreover, there turned out to be not one but several boulder-clays, showing that the Great Ice Age, as James Geikie felicitously dubbed it, was a complex era of alternate cold glacial and comparatively warm interglacial periods. Great was the controversy over this; the older men strenuously insisting that the Glacial Epoch, like the first French Republic, was one and indivisible. In Scotland, among the doughtiest champions of the new views were James Geikie and your old acquaintance Robert Logan Jack—whom you see I have known for over forty years. In England, Searles-Wood junior and F. W. Harmer had insisted on a similar state of things in East Anglia, and I soon found the same true of the midland counties; and a pretty tough fight we had to get our official heads to come round to our views. Anyhow I convinced Sir A. C. Ramsay, as you will see in his Geology of Great Britain.

In 1874 James Geikie published his "Great Ice Age," which practically settled the question, at least for us field geologists who were daily mapping the beds. Meanwhile I had gone to Brandon and had arrived at conclusions curiously like Geikie's, even to discovering a new series of interglacial beds, in fragments, but unmistakable, to which I gave the name of Brandon Beds. Also I had found that the chief boulder-clay differed in constituent matter according to the beds it passed over. From the nature of things this was much clearer in England than in Scotland. I wrote to Geikie, who

at once came to Brandon to see my evidence, and I showed him glacial clay that was pretty nearly all chalk, much to his surprise and delight. Amund Helland, the Norwegian geologist, had recently returned from Greenland, where a study of the ice had converted him to Geikie's views, and as soon as he heard of my work he hurried to England and a glorious time we had together before I packed him off to Geikie in Scotland. Then Geikie and I spent part of a summer in the Outer Hebrides working out their glacial history. Meanwhile a second edition of the "Great Ice Age" was called for and I wrote the better part of two chapters for it. Just as it was about to be issued I found my first implement in my Brandon Beds, sent Geikie the glad news, and he was able to note the fact in his preface.

As regards man's remains the case stood thus :—M. Boucher de Perthes had discovered what he believed to be flint tools in the gravels of the Somme associated with the remains of extinct animals, the mammoth, woolly rhinoceros, &c. Great was the stir, great the indignation at presuming to aver that man was more than 5,000 years old. The thing was impossible, impious, and patently absurd. No mention of such a thing occurred in any Hebrew or Greek text or in any of the commentaries, and this pithy and conclusive reasoning settled the matter. It was one of those knock-down blows that convince everybody but the person aimed at. A commission containing Lyell, Prestwich, Lubbock, Tylor, and others went over to Abbeville and Amiens, looked into the matter, were convinced, and from that time no geologist doubts man's contemporaneity with the mammoth. Here is one of the original Abbeville implements from Tylor's collection. It dates from about three years before I knew him (exhibited).

Then my good old Quaker friend William Pengelly was making similar finds in Kent's Cavern, Torquay, and soon a perfect rage for cave-hunting set in, in which my colleague Boyd Dawkins distinguished himself. Edward Tylor some years before had gone to the West Indies for health's sake, and in Havanah met Mr. Christy the rich London hatter, who was then making his unrivalled anthropological collection. The two went to Mexico to study its antiquities, and this made Edward Tylor an anthropologist whose name is now familiar in our mouths as household words. Among the things Tylor elucidated was the origin of certain strange fluted stones, which

he showed to be the cores from which the flakes for making spear and arrow heads were struck. I have the original obsidian core that led him to the solution (exhibited). John Evans—the Sir John of later date—collected stone and bronze tools assiduously, and had produced his great work on the Stone Implements of Great Britain. It is a splendid catalogue, but he was not much of a geologist. Sir John Lubbock, afterwards Lord Avebury, did us the incomparable service of inventing the terms "Neolithic" and "Palæolithic" for the two classes, polished stones, &c., as contrasted with the older, ruder, unground weapons till then known as drift implements, and he was the first not only to insist on the difference of their ages, but to show that even the drift implements of the gravel were not all of one age. Then Mr. Christy financed M. Lartet and others to work out the caves of Dordogne, which yielded among other treasures the now celebrated contemporary portrait of the mammoth engraved on his own tusk.

This then was the state of affairs:—James Geikie and I were up against three problems whose inertia was immense. Of course others were in the fray, especially Searles-Wood junior and F. W. Harmer in East Anglia, but I think we two stood most of the blows. Naturally I got a double share, for I had committed the enormity of slighting Bishop Ussher's chronology, and I assure you the Authorised Edition has the ballistic power of a siege-gun, especially when propelled by Calvanistic cordite. The battle raged on three fronts—the theological, the interglacial, and the Adamic, if I may so put my particular field of action. I should like to give due credit to others who were in the fray—Mortillet, Rutimeyer, Tiddeman, and many another veteran—but this is not a treatise, 'tis but a bit of personal reminiscence.

As regards the relics of man, the gravels of France and England had yielded bounteous spoil of implements; a memorable visit of English geologists to the Somme had formally received the outcast *haches de silex* of M. Boucher de Perthes within the pale of humanity; here is one of the tools brought back by A. Tylor from that memorable meeting. Caves were yielding up their treasures, and the great fact of man's contemporaneity with animals now extinct could never more be doubted. Sir John Lubbock was among the first to stress the fact that even in the gravels there was evidence of at least two distinct periods, one pertaining to a colder, the other to a warmer, climatic condition.

But everyone thought these things were post-glacial, and the orthodox ghost of good Bishop Ussher was not perturbed.

BRANDON.

I chose Brandon for my headquarters for anthropological reasons ; it was the centre of an area brimmed to overflow in stepping-stones of our dead selves, from tumuli where bronze fibula lay cheek by jowl with flint arrow-head and polished celt, to old mines wherein the early knapper had quarried black flint with deer-horn pick ; and the gravels of the river-banks were deposit-banks of palæolithic riches. Moreover it was the only surviving seat of the gun-flint makers, who still send these quaint survivals, weekly, by tens of thousands, to the Arctic wilds of Siberia and Russia and the Hudson's Bay Territory, for the fur-hunters whose warmly gloved fingers could not manipulate the tiny percussion cap. Canon Grenwell had opened a few of the ancient flint-mines at Grime's Graves, and in a fine paper had dropped the seed of a pregnant idea that the modern gun-flint industry might be the lineal descendant of the neolithic flint trade.

I received official permission to devote as much time as was needed to work out the story of this dying industry.

I became a flint-knapper and my siliceous education as a workman was complete. I became partner in a gun-flint shop and flint mine. The result was I was able to prove that the gun-flint trade was the oldest in Europe, with continuity from then backwards at least to neolithic times, for I learn that since my time it has been thought the Grime's Graves pits are late palæolithic. I showed that all the knapper's tools were but iron and steel replicas of the stone and bone implements of eld : that even some of the words of the lost language were in daily use, and that the knapper himself belonged to the neolithic type ; not only his tools but his body was age-old.

Meanwhile mapping went on, and I very soon became convinced that the palæolithic implements I found in plenty were not all of the same age, that some indeed were derived from older deposits, as you may get Coralline Cragshells in the Red Crag.

James Geikie had thrown out the bold suggestion that the river-gravels with palæolithic implements pertained to glacial times : his argument being that their northern limit coincided pretty closely with the southern limit of the later boulder-

clays, and were entirely missing from the area that had been ice-worn in the later cold spells, though the caves (as in Yorkshire), protected from the ice, yielded these tools not rarely. This was my nest-egg, upon which I brooded, and from which I hatched my own poor, pestered pullet. If, I argued, the crude man of the crude weapon followed up retreating ice and retreating reindeer he was the original cold-foot, but a plucky fighting-man. He must have gloried in the brave north wind which hardened his thews and kept him fit—he was of a race apart. The man who kept behind him on the warm plains and plateaus where

> They say the Lion and the Lizard keep
> The Courts where Jamshyd gloried and drank deep

must have been of other blood. Man in deed and in truth had even thus early segregated into diverse types. And so I set me to track him down.

For the glacial theory I then drove in my wedge showing that the Boulder Clay which marked the crest of the ice-wave, when glittering ice-pinnacles o'ertopped the vales of Thames and Severn, had not only gathered where it had not strawed, but oft-times and in divers places had strawed not far from where it had gathered—that the material filched from the blue-black Kimeridge Clay was carried unsullied forward onto the lighter blue Oxford Clay, and so on. No iceberg ever calved at the back of the North Wind knew enough geology to return its collection of rocks to their parent bed. The Chalky Boulder Clay got chalkier and chalkier as it spread over cretaceous East Anglia, till some of it held foreign matter in the scant percentage of the beastly powder of my childhood, *hydrargerum cum creta*.

It became clear that in pre-glacial times the chalk plateau around Brandon was, as might be expected, furrowed by brook and river, and then buried beneath the burden of the great ice rock-grinder. Then rain and frost and snow set to work to clean the plateau up again, and now only patches of glacial clay remain to witness of the days gone by. Some of these patches lay in hollows in the Chalk, and to my supreme delight beneath this Chalky Boulder Clay I found the shattered fragments of beds of sand and gravel and clay, clearly of fluviatile origin, obviously older than the glacial clay. They were the long-desired evidence of interglacial strata older than the climax of the Great Ice Age, and I named them the Brandon Beds.

Very soon after my fondest hopes were realised, and my Brandon Beds gave up their choicest secret—flint implements. I waited till I had got them in more than one locality—and they were as scarce as they were precious. I had of course notified my chiefs—they were not overwhelmingly congratulatory, and I don't think ever really convinced, though they were very nice to me, and allowed me to insert a meagre Bowdlerised edition of my views, in my official Report on the Gun-flint Industry.

Naturally the news created a sensation. Geologists were asked to gulp at least three heresies in one bolus. First, the Glacial Epoch was to be taken in three courses. Second, the salt of the Chalky Boulder Clay had lost its savour and was vapid freshwater stuff. Thirdly, that man went a hunting during fits of interglacial mildness between the cold chill working hours of glaciation.

Prof. T. McK. Hughes had left the Geological Survey and ascended the throne of Sedgewick at Cambridge. It was his delight, not once or twice in my poor Brandon story, to come down in full panoply of professorial dignity, with a tail of glorious undergrads, howk me out and go over the ground with me, and egg me on to expound, while he stood by mute. Then would he strip his sleeves, and standing on the Brandon Beds prove they were not there. He showed how my poor Boulder Clay was nought but solid chalk, and in fine demonstrated that I didn't understand geology but he did. Among those who listened and profited by this wisdom was the present Professor Marr, his successor (who has just exhumed me from oblivion), as he reminds me in a letter just to hand.,

I valiantly bearded the Cambridge lions in their den, and at the Philosophical Society meekly suggested that the genesis of man and man in Genesis were not convertible terms. After being soothed by the strains of a paper on Smith's function in a rectangular parallelepipedon I was called on. It was Hughes's hour of triumph, and he was glad he had been born. In presence of megaspores of dons, he got me down and rolled on me, he took me in his teeth and mangled me, and then flinging my remains onto a cane-bottomed chair, sat down panting but proud. One man alone had arnica for me—the Rev. Osmond Fisher, our greatest mathematical geologist, who had been over the evidence with me, and whose guest I was. A truly

great man. he went west but a few years since, having spent nearly a century benefiting the earth with his profound originality. He took casts of my implements, and I suppose they still exist. Dear old friend, the storm that raged never shook your faith in my work—for you knew. To him I owe my introduction to T. Belt. We all three went over the ground together and Belt was satisfied. Alas! he died shortly after, I believe in Nova Scotia.

The Sheffield meeting of the British Association was at hand, and my friend E. B. Tylor (not then knighted) was president of the Anthropological Section, then new, much neglected, and a little feared. By this time I had begun to wish my silvern speech had been coined into golden silence, and I intended to adopt the tactics of Brer Rabbit, but Tylor wouldn't have it. "You see, Skertchly," he placidly remarked, "neither I nor anybody else cares one spangled sequin about your views, but you will be an attraction and there's sure to be a row, and the Anthropological Section will get into the limelight." So I was offered up, and there *was* a row. Evans, Huxley, Newton (not the gravitation maker but the bird man), and all the other magnates whose words decided whether a thing was true and respectable, true and naughty, or neither, clubbed me as if each had inherited Thor's hammer. But I was never without one champion, and Sir John Lubbock stood up for me like—well, like Lord Avebury. Afterwards public opinion was too much for him, and he more than half recanted in Prehistoric Times.

Next came the meeting of the "Americanists" at Brussels. Evans, Lubbock, and I were selected to represent England. Lubbock was called to the South of France suddenly and couldn't come; Evans didn't come, I don't know why; and I stood there alone to represent Britannia, armed with a stone axe instead of a trident. I read a paper correlating the American and European old stone tools, and did it in my own hardened way. All the fine naturalists of Europe and some of the Americans were there. Again I had a solitary champion in that splendid fighter the Abbé Rénard, then holding a chair at Louvain.

A very serious accident caused me to leave the Geological Survey, and for months I was forbidden to read. For some time my wife and I wandered over France and Italy, and

I laid in new supplies of Tertiary and Post-Tertiary lore. Returning to England I found Lord Goschen had inaugurated the University Extension scheme, and I became one of the first lecturers. The London Institution asked me to lecture on Man, and I gave the first course of lectures ever delivered in London upon that subject at the famous institution in Finsbury Square. I also gave courses on Anthropology for the University Extension, naturally setting forth my views.

Then came the death of my beloved Alfred Tylor, and there was now nothing to keep me in England. I went to America and after many days read the story of pre-glacial man in California, as you may see in the Journal of the Anthropological Society for 1888, and a stone mortar from those old gravels of Butte County that I brought home is in the British Museum. The paper (read in my absence abroad) attracted but little attention, though S. Laing commented on it favourably in one of his thoughtful and delightful books. Even my friend Alfred Russel Wallace seemed oblivious of it, for he wrote to me that the remarks in his Darwinism were from his own observation—years after my visit. My American find shared the fate of its English co-sinner.

The evidence I relied upon in America was entirely geological —a fact I must dwell upon more particularly further on. The artifacts were chiefly stone mortars, and they had been known since about 1849. The American geological mind was revolving in a sort of "Californian wheel" which went round and round to this sort of reasoning: The mortars are of human origin, therefore the gravels are Post-Tertiary; the flora in the gravels is Pliocene, therefore the gravels are Tertiary: clearly the gravels cannot be both; clearly we cannot ignore the 300 artifacts that had turned up by 1888, and as the genesis of man is proved in Genesis, it is preferable to abolish the Pliocene plants and the 100 feet of overlying basalt and let Bishop Ussher be true and fossils and mortars (having no souls to be lost) be post-tertiaried into respectability. Faith was removing mountains.

An opportunity of visiting Borneo having arisen I eagerly embraced it. From the time when in the lecture theatre of the School of Mines (then in our Geological Survey building in Jermyn street, London) I had followed with keen delight Huxley's masterly description of the Neanderthal and other

old skulls, I had been disposed (unorthodoxly) to think man was of more than one race even when we first come upon his relics: and I had grown more and more to place weight upon the view many held, that as West Africa was the home alike of the black negro and the black gorilla, just as the Islands of the Sun were the abode of the brown orang-utan and the brown Malay, those parts might be "centres of origin." So I fondly hoped it might fall to me to unearth glacial man in Asia as I had done in Europe and America. But neither gravel nor cave in Borneo or other island in the Archipelago had any message for me. Far up the Kinabatangan River I found this (exhibited) the only old stone implement that rewarded me. It is old, almost certainly prehistoric so far as the Dyak race is concerned, but whether it be coeval with our neolithic or palæolithic, or still newer, there was not a particle of geological evidence to prove. It was reserved, as you know, for M. Dubois to exhume the much-debated Pithecanthropus—the man-monkey, or the monkey-man. The fight on this point has raged fiercely, and the fray has not yet come even to an armistice; but this I know, that if M. Dubois be lucky enough to catch a live one he will be puzzled whether to take it to the Zoo or the Sunday-school.

From Borneo I went to China, always in quest of the glacial sangreal, and travelled mony a weary fit over gravel and loess, in the vain pilgrimage. The China-Japan war sent me to Australia, for Othello's occupation was gone from the land of Confucius, and unless my old pupil Sun-yat-sen, elected President of China, should lure me from this newest to that quasi-oldest civilisation, here I shall come to rest. What I have done in Queensland to elucidate our ill-used cousin Blackfellow's history I have already hinted at.

THE NATURE OF THE EVIDENCE.

Let me now expound in some detail the nature of the evidence; and permit me once again to emphasize that the pre-glacial, inter-glacial, glacial, or post-glacial antiquity of man depends upon geological evidence, *and upon nothing else.* The characters of the bones and implements, the associated fauna and flora, have nothing whatever to do with the question. If the beds be, say, inter-glacial so must be the associated animal and vegetable remains; they sink or swim together. Yet this axiom was, by most, overlooked.

Put plainly the case was this :—I asserted three things: first that the Brandon Beds lay beneath the Chalky Boulder Clay, and were consequently anterior to the culmination of the Glacial Period ; secondly that the said Chalky Boulder Clay was the product of land ice and not of floating icebergs ; thirdly that the Brandon Beds contained remains of man in the flint implements I obtained in several, and the broken bones and old hearth I found in one place. I may here add that I found what I believed to be the site of an old tool factory of this age, and Professor Marr writes me that a party of (now penitent) geologists have recently spent some days in detailed examination of the locality, and their results confirm my views. It did not take ten minutes to refute them forty years ago !

Looking back to those early days I now feel sure that I was at that time the only man alive who could have deciphered the evidence. I am too old (and too far away) to be suspected of immodesty in so saying, but if you recall my very peculiar and special training you will see why I make the statement, and also the reason why I have burdened this paper with so many reminiscences. It is not I but the ferment I set up that matters : I was only the unrecognised enzyme.

It might seem a perfectly easy elementary problem to prove that one bed lay atop of another when they were before your eyes. But it wasn't. Whitaker and Hughes and Harmer (to cite a few) were competent field geologsts and skilful mappers of beds, of wide experience, yet they failed to read the sections aright ; and if they were nonplussed what was the fate of those whose scientific profundity would not enable them to distinguish between a cryptogam and a cryptogram ?

Take the above three friends of mine. How came it that they failed to recognise my Boulder Clay in many cases—they who had mapped so much of it ? It was largely owing to the reflex of the misleading theory of the marine origin of the boulder-clay. Clearly icebergs must in their melting moments shed their dry tears indiscriminately ; the seeds of future marine boulder-clays (to change the metaphor) must fall, some upon good soil, some upon stony ground, and some by the wayside ; there could be no connection between the stones in the clay and the rocks upon which they fell, if the berg were travelling high up above the outcrops of different kinds of rock. "Chalk to chalk" was not written in the iceberg's burial service.

Now I found that, though most of the boulder-clay (where thick) was made up of the detritus of distant rocks, much of the lower part was largely composed of fragments of the local rocks. This is exactly what must be the case if the ice were grinding over the surface of the ground, and precisely what could not possibly occur if the ice were simply floating over it. This my critics had not yet realised. The evidence was further obscured by the soluble character of chalk. It is fairly soft and takes glacial striæ beautifully, but, alas, carbon dioxide dissolved in rain-water has no reverence for geological records but avidly neutralises the acidity it suffers from by impartially absorbing chalk whether in glacial beds or in the parent rock. We folk got to recognise these well-licked relics of the boulder-clay even when they got into post-glacial gravels. In certain lights you could faintly trace the relics of the old striæ; these chalk pebbles had become palimpsests which you could decipher if you knew the language: A. C. Ramsay used to call them ghosts. Finally these chalk errants lost every trace of their glacial travels.

I found that over a good deal of Norfolk and Suffolk—chalk country—the Chalky Boulder Clay was often much more chalk than clay, more especially at its base. Over the area round Brandon in both counties the boulder-clay has been almost completely removed, but I found its remains preserved in hollows in the chalk surface, sometimes but a trace being left which one had well-nigh to accept by faith and not by sight. It was this very chalky, much denuded, badly dissolved clay that I offered them as the real article; naturally they would not have it at any ccst. But where, as at Culford, the boulder-clay was thick and unmistakable they accepted it and the Brandon Beds unconditionally. But the flint tools in the latter—well, they had to be explained away if they could not be explained. They were too few (at Culford two flakes only) to found such startling theory upon. They must have got in by accident; perhaps after all they were not really of man's handicraft. Short of deliberately accusing me of fabrication (in a double sense) they went through every conceivable logical contortion to obliterate their existence.

The Brandon Beds are a set of gravels, sands, loams, and clays, the most characteristic being pale-coloured, fine-grained loams, which, being suitable for brick-making in this clayless area, have been sought out and utilised. For the most part

they lie in small hollows in the chalk plain, and may attain a thickness of fifty feet, but are generally much thinner. They seldom cover more than a few square rods in area. They are usually finely bedded, but the bedding-planes now lie at any angle or may even be contorted. This is due partly to their porosity enhancing the rate of solution of the underlying chalk, which, wasting more quickly than that around, lets the Brandon Beds gradually down into a cup-shaped hollow. This is action from below. From above they have been tilted or contorted by the moving ice, which in places has protruded tongues of boulder-clay into or even beneath them. Often the ice has overridden without disturbing them, just as one may see a modern glacier do, which is nevertheless ploughing up the rocks hard by. The effects of these two opposite disturbing influences must be carefully disentangled if one is to read the record faithfully.

They are sometimes covered with several feet of typical boulder-clay, as at Culford, but generally the glacial overburden is thin, and often as at Broomhill only a trace is left, hard to make out; sometimes the boulder-clay has been completely worn away. But the Brandon Beds are invarably associated with the Chalky Boulder Clay, and even where they now lie uncovered it can always be proved that boulder-clay once overlaid them. The boulder-clay itself, over the chalk plain, lies preserved in just the same kind of hollows eaten into the chalk as do the implement-yielding loams and gravels. This curiously intimate association of isolated patches of the two deposits ("inliers" we call them) is the key to the problem.

STONES *V.* BONES.

Another objection was extracted from the stones themselves. See, they said, they agree not *inter se*; they are obviously of different types! Types! what had I to do with types? I was no typist, only a stenographer of facts. I only had one point to make, that these implements were older than the boulder-clay. Still, in a way, they had right on their side. Take these four specimens (exhibited) for example. This very crude flint they would now, I presume, call an eolith, of which more anon. This rolled, worn, rusty tool I suppose the French would dub a *coup-de-poing* of, say, Acheulian age. This beautiful pointed implement, finely flaked all over, would be unhesitatingly assigned to the

Magdalenian Age; but this ruddy tool, sharp almost as the day it was wrought, would puzzle them. I never saw one like it, and I know why; it happened to be a bit of "floor-stone" of good texture, but with what we knappers call a "wring" in it: it wouldn't, couldn't flake straight; the flakes would take on a curve, and so it has an individuality, it is a type unto itself. I found it in tough clay (hence the sharpness of its edges) near West Stow in the only hearth of this date I ever came across. It was associated with quantities of broken, pounded-up bones. I think its maker fashioned it sitting by the camp-fire into which it accidentally fell, which accounts for its burnt, red hue, and partly for its sharpness, for it has hardly been used.

"Now," said the type-founders, "riddle me this riddle. How can these four distinct types come out of beds of the same age?" Well that was no business of mine: I was satisfied they did. Still I proffered two explanations, either or both of which may be true. First, I couldn't picture a race all of whose members were equally skilful handicraftsmen, and moreover with only a single idea in their capacious brain-cases. There must have been clumsy boys and clever boys; and surely they had more than one use for tools—big, simple implements for rough work, more delicate ones for fancy work. You can buy a half-crown Waterbury and a hundred-guinea English lever in the same shop; and in the Outer Hebrides James Geikie and I watched a fine old grandmother at her spinning wheel in a cot of neolithic architecture and furnishing, while her bonny grand-daughter, a real Princess of Thule, sat using a Singer sewing-machine.

Types had no charm for me then. We had too few specimens to found classifications upon. Classifications are apt to be rather the needs of the museum than the necessities of history; sometimes the classification is more curious than the curiosity it labels. Hear what comfortable words a wise man utters in the year of grace one thousand nine hundred and eleven: "The value of stone implements in deciding upon the age of deposits (whether in caves or elsewhere) depends upon the intimacy of the relation existing between various forms of implement and strata of different age. How close that intimacy really is, has been debated often and at great length. Opinions are still at variance in regard to details, but as to certain main points, no doubt remains." I might quote

other authors to the same effect, but I gladly cite the above from Dr. W. L. H. Duckworth's "Prehistoric Man" for the kindly manner in which he has gathered the bread I cast upon the waters so long ago, and with friendly hand laid it, as he thought, upon my grave. I could not relegate him to the indignity of a footnote as if my gratitude, like Milton's land of no free-will, showed

"Only what one needs must do, not what one would."

I mentioned eoliths awhile back. Well, I found them by scores, and I will venture to pick out blindfold any worked flint or chert or bit of quartzite from naturally fractured stones, as long as my thumb has a tactile corpuscle left in working order.

Now as to Bones. As I had only stones to show, my critics demanded bones. Bones are so much more satisfactory than stones, they said in England then as they say in Queensland to-day. I hadn't any human bones to show; I didn't stock the Brandon Beds or I'd have had a good supply, enough to go all round. It looked as if my osteological friends had taken the motto *De mortuis nil nisi bonum,* and rendered it—*De mortuis*, concerning Prehistoric Man; *nil*, you can know nothing; *nisi bonum*, unless you've got his bones.

Besides, had the Brandon Beds been as full of bones as a glue-makër's yard it wouldn't have mattered to me; it would miss my point entirely; it would do nothing to settling the question of the age of the tool-bearing beds—folks would never grapple this, the important question.

Then as to types—as to races. With the memory of the Neanderthal and other palæolithic finds such as the rich stores of La Madeline, which I discussed with Lartet, I was strongly of opinion that in palæolithic as in modern times more than one human race was playing its part on earth. But with the race question I had no personal connection. Racial characters must be worked out in museums, and I was a field man. It was the history, not the genealogy, of man that was my *métier*. Indeed the very first attempt at dividing the palæolithic age into stages was published by me in my book on the Fenland in 1878, and repeated in my official work on Gun-flints the following year. This was an additional crime; nevertheless, though this primitive effort had, naturally, many flaws in detail, succeeding research has confirmed my main contention; and

now, so far from there being *a* Palæolithic Man, anatomists are making of him almost as many races or subspecies or even species as there are skeletons, and they are still undecided as to the exact age of most of them. I assert now, as I did then, that bones of themselves tell us nothing of their date but only of their race, and an old race may exist to-day. On the Labrador coast you can knock fossil Lingulellas out of Cambrian rocks, and dig their living descendants from the mud at the cliff-foot. Our dear friend Pithecanthropus may be Pliocene or Pleistocene; he might be alive to-day, but his mere bones would not tell us when he lived—the rocks are the only true timekeepers.

However, if I failed to deliver human bones, I sent to the Geological Survey Office a good-sized hamper full of bone fragments from the hearth at West Stow above mentioned. They were mostly quite small bits, but I recognised a few teeth of oxen and deer. Huxley, who was our palæontologist, took but the palest interest in them, but he reported officially that they were mostly too fragmentary for identification, though *Cervus elaphas* seemed to be among them. I mentioned this at the Cambridge Philosophical Society and it proved a *bonne bouche* to Hughes, who after tearing it to bits proceeded to pick my bones in great style. Did I not know that *Cervus elaphas* was late Pleistocene? If that deer-tooth came out of the Brandon Beds it settled the whole matter; they were demonstrably post-glacial. And the congregation (save Osmund Fisher) chanted "Amen." What a strained effort my reply seemed! I pleaded that I didn't find the label but only the specimen; that I only said the beast from whose jaw the tooth was extracted lived pretty near where he was buried; that Huxley only erected the tombstone and if he cut the wrong name on it the corpse wasn't altered thereby; finally that, if Huxley as dentist had got his patient's name right in his books, it proved the *elaphas* family more aristocratically connected than was suspected, that *elaphas* belonged to a county family and was not of clodhopper blood. It was of no avail, but the anecdote points a moral and adorns this tale: it shows that if anatomy be not tempered with geology bones become shillelaghs for decorous Donnybrooks.

Permit me here to put in a little moral on my own account. Remember that my finds were made in the course of my daily work, and that I could spare only too little time over each section, seeing that the powers (not the Geological Survey

powers) who paid us could only appreciate area. My own chiefs were very lenient with me; they sympathised, but not to the extent of letting me spend a few pounds in clearing sections. It was the same with the visiting public; a party of about fifty from Norwich argued a whole afternoon about the interpretation of my Brandon Bed tool factory, but were not game to ante-up a shilling a head to do some digging and settle the point. This year Professor Marr and some friends, he tells me, have put in a week's hard work there and find I was not very far out.

* * * * * *

Forty years have passed. Eoliths have come to their own. Man has been tracked far beyond the glacial period, at least to the times of the Red Crag. He proves to be of several races. And I think it is also certain that though a race may become modified it seldom, if ever, dies out. All the points I claimed have proven to be points of light.

I believe man developed very rapidly, but only after he had learned to utilise fire. That this occurred in a cold region. It provided him with warmth and later with cooked food. But chiefly it gave him leisure, it doubled his life, and sundown no longer meant the close of a working day. How the leisure hours by the camp-fire split his genio-hyoglossus muscle, as boys used to split starlings' tongues, to make him talk, I will tell, with other heresies, unless the clock strikes ere I overcome my repugnance to ink, and will again do the penance of the pen.

Then, too, I believe man very early branched into two and only two sections—the Negro, and the rest. The Negro took as blind a path as my old acquaintance Orang Utan, and can no more advance than he can. To say he has never had a chance, that he has always been downtrodden, is sentimental flapdoodle. He has been on earth as long as we have; he was in contact with civilisation thousands of years before we were; in fine, he had a better chance than we had. He is what he is because he is what he is.

I think it certain that white races may gradually enlarge their borders successfully; they cannot emigrate to distant lands and permanently occupy them. The White Man cannot live in the United States or in Australia without transfusion of blood from the homeland.

I can see no, or very little, proof that man has increased in brain-power since palæolithic times; he has simply a bigger stock of knowledge—he knows more, he is not wiser.

I am deeply grateful to you good Queenslanders for your kindly forbearance to-night. It may seem to have been a night of amazing indiscretion: that this being the Royal Society, and I an old President of yours, should have made my discourse dry. I must only plead the qualities of old wine—the best champagne is dry.

And now to look forward. I see, as Charon shuts off petrol nearing the jetty on the far side of the dark waters, Professor Thomas McKenny Hughes clear-cut against the western sky-line, atop of a high-level gravel escarpment of the Styx River, stretching out a hand to me. I hear his cry of welcome, and as I step ashore he whelms me with confetti made of torn fragments of his contra-Skertchly papers, and as we link arms he murmurs, "Come to the Mammoth and have tiffin with me, and meet your old friend *Homo Brandonbedensis*; he is a Pal of mine."

Contributions to the Queensland Flora.

By C. T. White, F.L.S., Government Botanist,
and
W. D. Francis, Assistant Government Botanist.

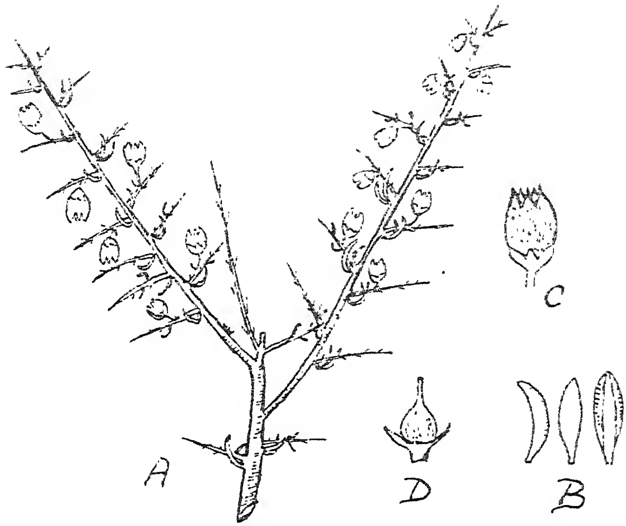
(*Read before the Royal Society of Queensland, 26th Sept., 1921.*)

Since the publication of the "Queensland Flora" by the late F. M. Bailey, that author published various papers entitled "Contributions to the Queensland Flora," in the pages of the "Queensland Agricultural Journal" and as Botany Bulletins of the Department of Agriculture and Stock. Since his death in 1915, contributions to the flora of the State from the pens of J. F. Bailey and the present authors have appeared in the form of Botany Bulletins of the Queensland Department of Agriculture and Stock. Circumstances at present make it unlikely that any further Botany Bulletins will be issued for some time to come, and the present paper is the first of a series which we hope to publish in these Proceedings. It contains descriptions of new species, records of plants not previously found or recognised in the State, and critical notes on other species. Much of the material has come to hand through collections received for identification from correspondents in different parts of the State.

Order STERCULIACEÆ.

Sterculia quadrifida R. Br. The under side of leaves often pubescent with stellate hairs, or velvety tomentose with stellate and simple hairs intermixed.

In the description in the "Queensland Flora," i, 136, and in previous publications, the leaves are described as glabrous on both sides, but we recently received from the Rev. N. Michael some specimens collected at Mount Julian, Proserpine district, with the leaves decidedly velvety pubescent underneath, and on looking through the material in the Queensland Herbarium several specimens were noticed with the leaves bearing numerous and fairly crowded hairs approaching those of the Mount Julian specimens.



Text-figure 1.

Cryptandra armata sp. nov. A, shoot, nat. size. B, side, front, and back view of leaf, × 3. C, flower, × 2. D, pistil. × 2½.

ORDER RHAMNACEÆ.

CRYPTANDRA Sm.

C. armata sp. nov. (Text-fig. 1.)

Frutex, ramulis spinescentibus novellis puberulis; foliis glabris lanceolatis vel oblongo-linearibus vel fere teretibus marginibus revolutis 3-5 mm. longis; floribus breviter pedicellatis lateralibus, solitaribus vel breviter racemosis: bracteis rotundatis marginibus ciliolatis; calycibus extus sericeo-pubescentibus, urceolatis 5-6 mm. longis, lobis triangularibus tubo tripto brevioribus; petalis cucullatis; antheris inclusis cordatis, filamentis liberis; ovario dense pubescente, stylo glabro.

A thorny shrub. Young branchlets finely pubescent. Thorns 3-5 lines (6-10 mm.) long. Leaves clustered at the base or scattered in the lower part of the horizontally spreading, pungent thorns, oblong-lanceolate, oblong-linear or almost terete, with closely revolute margins, curved in the dried specimens, 1½-2½ lines (3-5 mm.) long. Flowers on very short pubescent pedicels arising laterally from the thorns, single or very shortly racemose. Imbricate brown bracts broad and rounded, with minutely ciliate margins, less than 1 line (2 mm.)

in length. Calyx silky pubescent outside, broadly urceolate, $2\frac{1}{2}$-3 lines (5-6 mm.) long, lobes triangular, about one-third of the total length of the calyx. Petals slightly protruding from the sinuses of the calyx, white, minute and hood-shaped, the enclosed anthers on very short free filaments, broad, cordate and dorsifixed. Ovary adnate by its broad base only, the free part densely pubescent, convex or broadly conical, obscurely flanged towards the base or the disk inconspicuous. Style glabrous and slender, about $1\frac{1}{2}$ line (3 mm.) long ; stigma truncate.

Hab. : Barakula, a few miles north of Chinchilla, *J. E. Young*.

The rigid and pungent thorns of this species are like those of *C. spinescens* Sieb., to which it is allied. From that species, however, it is distinguished by its larger, urceolate, non-stipitate calyx-tube and its conical ovary adnate by its broad base only. From the various forms of *C. amara* Sm. it can be distinguished by its very thorny branches and lateral flowers often solitary and its urceolate calyx-tube.

Order SAPINDACEÆ.

Ratonia punctulata F.v.M. Hitherto the flowers of this species were unknown. Following is a description of them :—Panicles in the upper axils, shorter than the leaves, narrow and raceme-like or with a few slender raceme-like branches, rhachis slender. Flowers pedicellate, about 2 lines (4 mm.) in diameter. Calyx divided to the base ; lobes 5, glabrous, imbricate, one or two outer ones smaller than the others, orbicular, concave, with hyaline margins, about 1 line (2 mm.) in diameter. Petals only one or two in each flower examined, opposite to the smaller calyx-lobes, glabrous, cream-coloured, orbicular, about 1 line (2 mm.) in diameter. Stamens 8, about 1 line (2 mm.) long ; anthers glabrous, cordate-ovate ; filaments broad, ciliate, slightly longer than the anthers. Ovary glabrous or slightly pubescent, ovate or obscurely trigonous, tapering into a short style.

Hab. : Gregory River, near Mount Dryander, Proserpine district, *Rev. N. Michael* (flowering specimens).

Order LEGUMINOSÆ.

Burtonia foliolosa Benth. Fruiting specimens of this plant were previously unknown. The following description has been drawn up from material recently received :—Pod obliquely globular, compressed, $2\frac{1}{2}$ lines (5 mm.) in diameter. Each pod generally contains 2 globose seeds, about $\frac{1}{2}$ line (1 mm.) in diameter, borne on a funicle about 1 line (2 mm.) long.

Hab.: Between Blackall and Jericho, Central Queensland, *D. W. Gaukrodger.*

Desmodium triflorum DC. Prodr. ii, 334. Not previously recorded for the State.

Hab.: Kelsey Creek, near Proserpine, *Rev. N. Michael*: Enoggera Creek and Toowong, Brisbane district, *F. M. Bailey.*

Distribution: Cosmopolitan in the tropics.

Order MYRTACEÆ.

KUNZEA Reichb.

K. flavescens sp. nov.

Frutex, ramulis novellis pubescentibus: foliis alternis oblanceolatis vel obovatis, mucronulatis vel acutis, supra glabris, subtus aliquando puberulis; inflorescentiis terminalibus capitatis vel subspicatis; bracteis bracteolisque orbicularibus concavis extus pubescentibus; floribus subsessilibus; calyce campanulato, extus dense pubescente, lobis lanceolatis: petalis albis orbicularibus glabris; ovario triloculato.

A shrub, the young shoots, branchlets, and calyces pubescent. Branchlets terete. Leaves rather crowded, alternate, very shortly petiolate, oblanceolate or obovate, mucronulate or acute, glabrous above, sometimes very minutely pubescent on the under side, venation obscure or occasionally the midrib and sometimes a longitudinal nerve on each side of it visible; 2-4 lines (4-8 mm.) long, 2-3 times as long as broad. Inflorescence terminal, capitate or shortly spicate, about $\frac{1}{2}$ in. (1·3 cm.) in diameter. Bracts and bracteoles similar, orbicular, concave, pubescent outside, over 1 line (2 mm.) in diameter. Flowers subsessile. Calyx campanulate, densely pubescent outside; tube nearly 2 lines (4 mm.) long; lobes 5, lanceolate, about half as long as the tube. Petals 5, white, orbicular, glabrous, nearly 1 line (2 mm.) in diameter. Stamens indefinite; filaments slender, nearly 2 lines (4 mm.) long; anthers minute. Ovary filling the lower part of the calyx-tube, 3-celled, with a single ovule in each cell; style 2 lines (4 mm.) long; stigma flat, orbicular.

Hab.: Crow's Nest, Darling Downs, *Dr. F. Hamilton Kenny.*

K. Cambagei Maid. & Betche, a New South Wales species, is closely allied to this species, but is distinguished by its lateral and smaller inflorescence, smaller leaves (4-5 mm. long), narrow bracteoles, and 2-celled ovary.

ORDER RUBIACEÆ.

DENTELLA, Forst.

D. minutissima sp. nov.

Herba minutissima subcarnosa foliis petiolatis minutis oppositis ovatis vel orbicularibus ·5-1 mm. longis, marginibus pilis albis hyalinis obsitis ; floribus solitariis sessilibus ; calycis tubo globoso setis hyalinis minutis obsitis, limbo 5-lobato ; corollæ tubo cylindrico 5-lobatis, lobis ovatis obtusis ; staminibus subinclusis ; capsulis globosis vel ovalibus setis hyalinis obsitis ; seminibus angulatis minute punctulatis.

A small fleshy herb creeping in mud and rooting at the nodes, forming a dense, green, carpet-like covering on the soil, all its parts thinly sprinkled with minute hyaline setæ. Leaves minute, opposite, fleshy, ovate or orbicular, obtuse, ¼-½ line (·5-1 mm.) long, on petioles of ¼-½ line (·5-1 mm.). Flowers sessile, solitary in the axils, 3-4 lines (6-8 mm.) long. Calyx about one-third the length of the flower, sparingly puberulent with minute gland-like hairs; tube globular, covered with minute setæ about one-third line (·6 mm.) in diameter; limb cupular, about ⅔ line (1·3 mm.) long, divided to its middle into 5 ovate lobes. Corolla-tube cylindrical, about 2 lines (4 mm. long) lobes 5, ovate, obtuse, about 1 line (2 mm.) long. Anthers linear, placed near the orifice of the corolla-tube, on apparently short filaments. Style slender, 1½ line (3 mm.) long, with 2 slender stigmatic branches. Capsules mostly sessile on the stem or in its forks and subtended by adventitious roots, globose, oval or compressed and 2-lobed, often oblique, covered with minute hyaline setæ, under 1 line (2 mm.) in diameter, 2-celled. Seeds several in each cell, angular, minutely pitted, about ¼ line (·5 mm.) broad.

Hab. : Elderslie, near Winton, *F. L. Berney*.

The chief distinctions between the species here proposed and *D. repens* Forst. are—

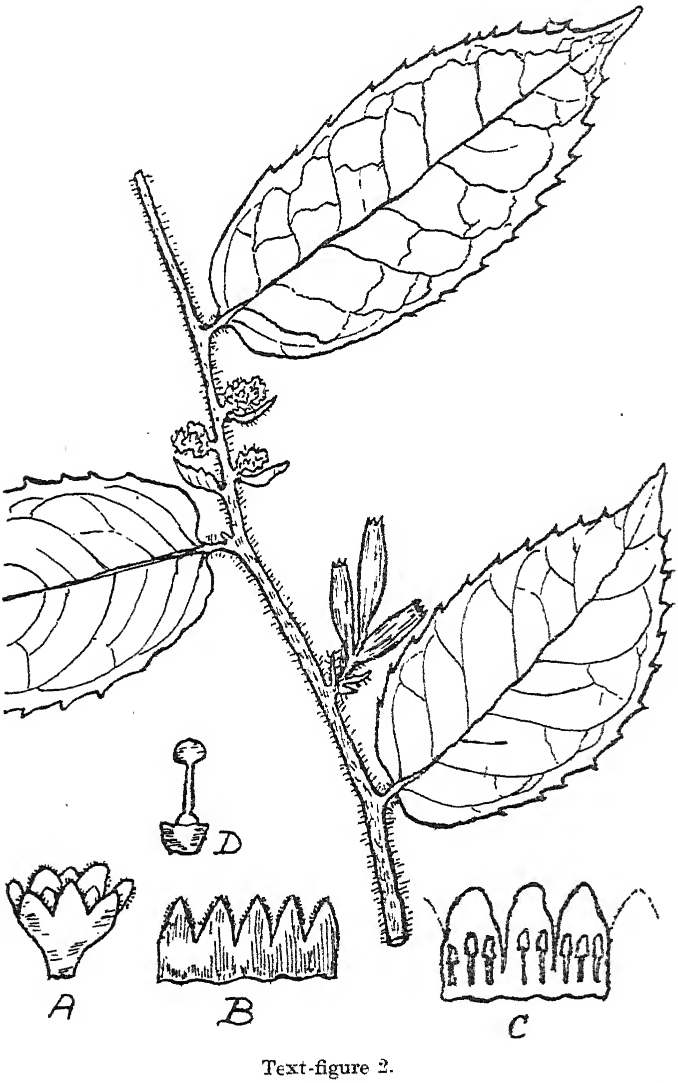
Leaves mostly above 1 line in length.
  Anthers placed near middle of corolla-tube .. *D. repens*.
Leaves all under 1 line in length.
  Anthers placed near orifice of corolla-tube .. *D. minutissima*.

ORDER SAPOTACEÆ.

Hormogyne cotinifolia A. DC. Fruiting specimens of this plant were previously unknown. Following is a description of them :—Fruit green (perhaps immature), subtended by the

persistent calyx-lobes, oval, scarcely succulent, attaining ½ in. (1·3 cm.) in length, surmounted by the persistent slender style which measures about 3 lines (6 mm.) long ; seeds 1-3, obliquely oval, smooth and shining ; hilum nearly as long as the seed.

Hab. : Nanango, extreme south of Burnett district, *C. H. Grove* (fruiting specimens).



Text-figure 2.

Symplocos Hayesii sp. nov. A, single flower, × 6. B, calyx laid open, × 6. C, part of corolla laid open showing stamens, × 7. D, pistil, × 7.

ORDER STYRACACEÆ.

SYMPLOCOS Linn.

S. Hayesii sp. nov. (Text-fig. 2.)

Frutex, ramulis dense hirsutis; foliis breviter petiolatis, lamina glabra, serrata ovata, ad apicem acuminata ad basem rotundata vel subcordata; petiolo dense hirsuto; inflorescentiis lateralibus, breviter spicatis vel fere capitatis bracteatis; rhacide hirsuta; floribus sessilibus vel subsessilibus glabratis campanulatis, calycis lobis lanceolato-ovatis marginibus ciliolatis; corolla alte in lobos ovatos divisa; staminibus ca. 15; fructibus elliptico-oblongis vel fere cylindricis.

A slender shrub, the young shoots, branchlets, petioles, and bracts clothed with long hairs. Leaves on petioles about 1½ line (3 mm.) long, ovate, prominently acuminate, rounded and slightly cordate at the base, margins acutely serrate, midrib, lateral nerves, and the larger reticulate veins visible, especially on the under side where they are slightly raised, 2¼-4½ in. (5·7-11·5 cm.) long, twice to 2½ times as long as broad. Inflorescence shortly spicate or almost capitate, mostly lateral, under ½ in. (1·3 cm.) long, mostly subtended by a leafy, lanceolate, serrate bract, the bract sometimes attaining ½ in. (1·3 cm.) in length. Bracts subtending each flower ovate-lanceolate, acuminate, clothed with a few long hairs, especially on the outside, nearly 1½ line (3 mm.) long; bracteoles narrowly triangular, hirsute, under 1 line (2 mm.) long. Flowers sessile or nearly so, glabrous, campanulate, about 1½ line (3 mm.) long. Calyx about 1¼ line (2·5 mm.) long, divided to about the middle into 5 lanceolate-ovate lobes, their margins minutely ciliate. Corolla slightly exceeding the calyx, divided to about two-thirds of its length into 5 ovate lobes. Stamens about 15, inserted near the base of the corolla-tube, shorter than the corolla. Summit of the ovary protruding from the calyx-tube. Style about ½ line (1 mm.) long; stigma prominent, depressed globular. Fruit indehiscent, scarcely succulent, elliptic-oblong or nearly cylindrical, about ½ in. (13 mm.) long, crowned by the 5 calyx-lobes surrounding the remains of the style, 2-celled, containing in each cell a single narrow seed nearly ½ in. (1·3 cm.) long.

Hab.: Glenallan, Atherton Tableland, *H. C. Hayes*.

The above species is closely allied to *Symplocos paucistaminea* F.v.M. & Bail., from which it can be distinguished by its bracteate, short spikes

or heads of flowers, its thinner indumentum and glabrous under side of its leaves, and especially by its long, almost cylindrical fruits. In the shortness of the inflorescence and the shape of the fruit it approaches *S. Bauerlenii* R. T. Baker, from which, however, it is easily distinguished by its densely hirsute character and large bracts of the inflorescence.

ORDER SCROPHULARINEÆ.

BONNAYA Link and Otto.

B. veronicæfolia Spreng., var. **angustifolia** var. nov.

Herba debilis, caule simplici, foliis anguste linearibus (1·3-3·9 cm. longis, 2-4 mm. latis), inflorescentiis terminalibus racemosis vel raro floribus solitaribus axillaribus.

An erect, scarcely branched herb attaining 7 in. (18 cm.) in height. Leaves linear, remotely toothed, ½-1½ in. (1·3-3·9 cm.) long, 1-2 lines (2-4 mm.) broad. Inflorescence lengthening into a terminal raceme or rarely the flowers solitary in the axils. Pedicels slender, attaining ½ in. (1·3 cm.) in length. Flowers very slender, about 3 lines (6 mm.) long; calyx about half the length of the flowers. Capsule terete, linear, attaining ½ in. (1·3 cm.).

Hab.: Kelsey Creek, near Proserpine, *Rev. N. Michael.*

This variety differs from the type in its erect, scarcely branched habit and much narrower leaves. In appearance it bears a very close resemblance to the Asiatic *Vandellia angustifolia* Benth.

ORDER LABIATÆ.

WESTRINGIA Sm.

A Revised Account of the Queensland Species.

The genus *Westringia* is confined to Australia and consists of about twelve known species. The collection of a new species at Yelarbon in Southern Queensland by one of us (C.T.W.) led to a careful examination of the material in the Queensland Government Herbarium, and it was found that the account of the Queensland species published by the late F. M. Bailey in the "Queensland Flora," part iv, pp. 1205-1206, was badly in need of revision. One more new species and a new record were found amongst the herbarium material, and it was also found that no authentic Queensland material existed of *Westringia rosmariniformis* Sm. and *W. rigida* R. Br. The following amended account of the Queensland species of the genus is therefore offered herewith :—

Key to the Species.

Calyx glabrous.

Calyx-lobes about as long as the tube .. .. *W. glabra.*

Calyx-lobes much shorter than the tube .. *W. Cheelii.*

Calyx pubescent.

Leaves with thickened margins, but scarcely revolute, under side glabrous.

Leaves under 2½ lines long, obovate .. *W. parvifolia.*

Leaves 3-8 lines long, linear-elliptical ... *W. tenuicaulis.*

Leaves with recurved margins, lanceolate, under side white tomentose .. .. .. *W. rosmariniformis* var. *grandifolia.*

Leaves with revolute or recurved margins, linear, 4-18 lines long, under side usually clothed with scattered strigose hairs .. .. *W. eremicola.*

W. glabra R. Br. Prod. 501.

Hab.: Shoalwater Bay, *R. Brown.*

The identity of the New South Wales and Victorian specimens with those from the type locality in Tropical Queensland is a subject which seems worthy of careful investigation. The specimen from Dawson River referred to by Bailey in the "Queensland Flora" belongs to *W. Cheelii.*

W. Cheelii Maiden & Betche, Proc. Linn. Soc. N.S.W. xxxv, 792 (1910).

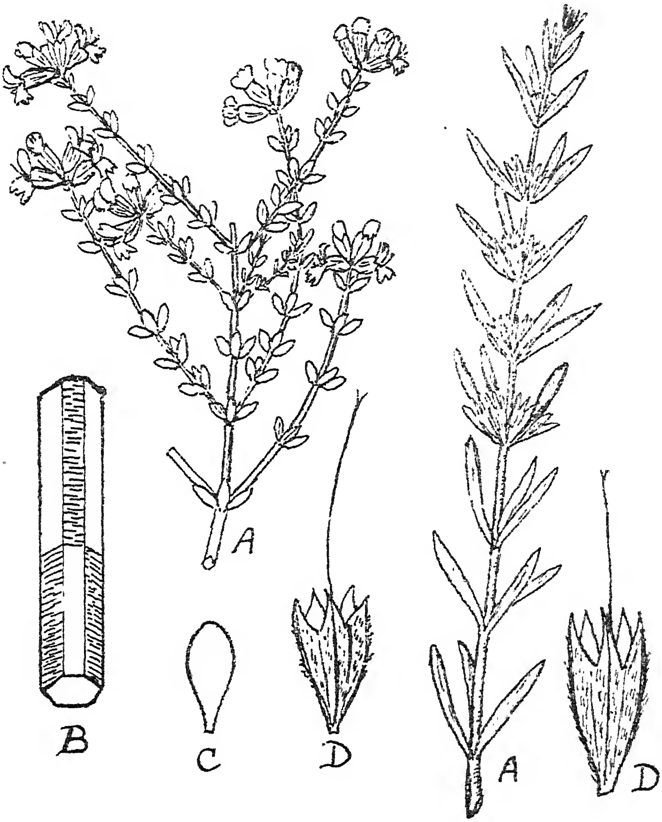
Hab.: Dawson River, *Dr. T. L. Bancroft*; Roma, *Rev. B. Scortechini*; Barakula, *J. E. Young.*

W. parvifolia sp. nov. (Text-fig. 3.)

Frutex parvus, ramulis ternis hexagonis novellis minute pubescentibus; foliis minutis ternis (2-4 mm. longis) subsessilibus obovatis vel ellipticis; floribus breviter pedicellatis (pedicellis ca. 1 mm. longis) axillaribus sed apice ramosum in capitulis fere terminalibus confertis, capitulis 3-7 floris; calycis pubescentibus, campanulatis, tubo costato, limbo 5-lobo, lobis deltoideis; corolla superne utrinque dense pubescentibus, staminibus exsertis; pistillo glabro.

A spreading shrub of 2-3 ft. in height, the young shoots and inflorescence pubescent with minute, white, appressed hairs. Branchlets often hexagonal; three alternate surfaces of each internode transversely striate or wrinkled; in adjoining internodes the order is reversed and the surface, which is plane in the internode above and below, is marked by the transverse wrinkles. The insertions of the leaves and branchlets are generally subtended by a wrinkled surface. Leaves in whorls

of three, very small, obovate or elliptical, subsessile, margins slightly recurved, from under 1 line to 2 lines long. Flowers on pedicels of ½ line (1 mm.) or less, in the upper axils, forming terminal leafy heads of 3-7 flowers. Bracts minute, linear, inserted at the base of the calyx-tube. Calyx pubescent, campanulate, with 10 longitudinal ribs, about 2 lines (4 mm.) long, the five broad, deltoid lobes less than half the length of the tube. Corolla hoary pubescent on both surfaces in the upper



Text-figure 3.

Left: *Westringia parvifolia* sp. nov. Right: *W. tenuicaulis* sp. nov. A, shoot, nat. size. B, portion of stem, × 4, to show transverse markings on alternate angles of the nodes. C, single leaf, × 5. D, calyx (in *W. parvifolia* × 4, in *W. tenuicaulis* × 3).

part, the tube slightly exceeding the calyx and the lobes about as long as the tube. Stamens exserted. Ovary glabrous, 4-lobed; style slender and glabrous, 2½ lines (5 mm.) long.

Hab.: Yelarbon, Southern Darling Downs, *C. T. White.*

In floral structure this species resembles *Westringia Cheelii*, which is readily distinguished from *W. parvifolia* by its larger leaves measuring about 3 lines long. The peculiar hexagonal stems with the transverse markings as described above are also very noticeable in our herbarium specimens of *W. Cheelii* from Narrabri (N.S.W.) and Barakula (Q.). *W. parvifolia* was generally seen growing in clumps of Spinifex (*Triodia* sp.) in the desert country near Yelarbon.

W. tenuicaulis sp. nov. (Text-fig. 3.)

Frutex erectus ca. 46 cm. altus, ramulis junioribus pubescentibus, foliis ternis vel rarius quaternis, linearo-ellipticis, basi sensim petiolatis; floribus subsessilibus axillaribus sed apice ramorum in racemis confertis; calycis pubescentibus campanulatis, lobis triangularibus acutis; corolla superne pilosa; pistillo glabro.

A plant of about 18 in. in height with a number of slender stems proceeding from the same rootstock, the young shoots and inflorescence pubescent with appressed hairs. Leaves in whorls of 3 or occasionally 4, linear-elliptical, narrowed at both extremities, the base gradually tapering into a very short petiole, margins slightly thickened but not revolute, with a raised midrib on the under side, 3-7 lines (6-14 mm.) long. Flowers subsessile, solitary in the upper axils or forming short, terminal, leafy spikes. Bracts at the base of the calyx-tube linear and minute. Calyx pubescent, campanulate, nearly 3 lines (6 mm.) long; lobes triangular, acute, more than half the length of the tube. Corolla pubescent in the upper part, the tube about as long as the calyx. Ovary glabrous, 4-lobed. Style slender, glabrous.

Hab.: Burrum River, *James Keys*; Lake Cootharaba, both in the Wide Bay district, *James Keys*.

W. tenuicaulis is allied to *W. eremicola* A. Cunn. and *W. Cheelii* Maid. & Betche, but it differs in habit from these species and is distinguished from the former by its non-revolute, glabrous leaves and from the latter by its larger leaves and longer calyx-lobes. Its habit suggests that it abounds in the so-called "wallum" country of the coast.

W. rosmariniformis Sm., var. **grandifolia** F.v.M. Herb. *W. grandifolia* F.v.M. ex Bentham "Flora Australiensis," v, 128.

Hab.: Granite Mountains, near Moreton Bay, Queensland.

Through the kindness of Professor A. J. Ewart, late Government Botanist of Victoria, we were enabled to see a specimen of *W. grandifolia*

F.v.M. The label bears the following particulars :—*Westringia grandifolia* F.v.M. (*W. rosmariniformis* Sm., var. *grandifolia* F.v.M.), Granite Mountains, near Moreton Bay, F. Mueller, 1857. In the "Flora Australiensis" and the "Queensland Flora," Glass House Mountains, which are not granitic, are given as the habitat. Although we know that locality well and have done a good deal of collecting over it, we have never been able to find this variety. It is much more likely that the Granite Mountains of Mueller refer to the Stanthorpe district, especially as the Glass House Mountains are none of them granitic. *W. grandifolia* does not seem sufficiently well differentiated from the common *W. rosmariniformis* to stand as a good species, and we have adopted Mueller's second herbarium name; Mueller himself dropped the species in his "Second Census of Australian Plants."

W. eremicola A. Cunn.

Hab.: Stanthorpe, *L. A. Bernays*; Toowoomba, *H. A. Longman*; Helidon (with leaves attaining $1\frac{1}{2}$ in. in length and occasionally quite flat), *F. M. Bailey*; Ipswich, *C. T. White*; Wellington Point, *J. Wedd*; Brisbane River, *F. M. Bailey*.

Excluded Species.

W. rosmariniformis Sm.

F. M. Bailey ("Queensland Flora," iv, 1206) records the habitat of this species as "Southern localities." There are no Queensland specimens of the typical form in the Queensland Government herbarium, and we think it better that it should be removed from the list of Queensland species until authentic material has been gathered.

W. rigida R. Br.

The specimens referred to by Bailey ("Queensland Flora," iv. 1206) in our opinion belong to *W. Cheelii*. It is recorded by Mueller for Queensland without definite habitat in the "Second Census of Australian Plants," but we think that it should be removed from the list of Queensland species until authentic material has been collected and placed in some recognised herbarium.

ORDER LAURINEÆ.

Cryptocarya australis Benth.

This species has a wide range in coastal Queensland, extending from the Tweed River in the South to the Cairns district in the North. In the Northern specimens as a whole the leaf is much larger and more attenuately acuminate. Some specimens from the Johnstone River collected by Dr. T. L. Bancroft have leaves up to $5\frac{1}{2}$ in. long and look so different from the typical form that we had drawn up a provisional description from them as a new species; the floral structure, however, is wholly that of *C. australis*.

ENDIANDRA R. Br.

E. crassiflora sp. nov.

Arbor ramulis novellis dense ferrugineo-pubescentibus; foliis petiolatis, ellipticis, supra glabris minute reticulatis, subtus glaucescentibus, nervis saepe pubescentibus; paniculis axillaribus quam folia brevioribus; floribus pedicellatis, glabris; perianthii tubo turbinato, segmentis ovatis vel suborbicularibus crassiusculis; staminibus perfectis 3, glandulis minutis, sessilibus; ovario ovoideo.

A tree. Young shoots, young branchlets, and rhachis of inflorescence ferruginous pubescent. Leaves petiolate, petiole 3-5 lines (6-10 mm.) long; lamina elliptical, apex rounded or obtuse or rarely obtusely acuminate, upper surface finely reticulate, under surface mostly glaucous with the midrib and principal lateral nerves prominent, raised, brown and often pubescent, 2-3 in. (5-7·6 cm.) long, twice to 2½ times as long as broad. Panicles very slender or almost raceme-like, in the axils of and much shorter than the leaves. Flowers shortly pedicellate, glabrous. Perianth turbinate, the tube obconical and as long as or longer than the lobes; lobes ovate or nearly orbicular, obtuse, thick in texture, the three outer ones broader than the three inner ones, over 1 line (2 mm.) long. Stamens 3, filling the throat of the perianth, subsessile, suborbicular or broader than long, about $\frac{1}{20}$-in. in diameter. On the outside of and at the base of each of the stamens are 2 minute broadly sessile glands sometimes scarcely visible. Ovary enclosed in the perianth-tube, ovoid, tapering into a short style. Fruit not available.

Hab.: Macpherson Range, South-Eastern Queensland, *C. T. White*, Feb. 1912.

This species appears to be allied to the Northern *Endiandra hypotephra* F.v.M., from which it is distinguished by its obtuse, rarely acuminate leaves and the absence of a prominent ring surrounding the stamens.

ORDER URTICACEÆ.

Ficus Watkinsiana Bail., Bull. No. 7 (1891) Dept. Agric., Brisbane (Botany No. 2), p. 18; "Queensland Flora," part v, p. 1472. *F. Bellingeri* C. Moore, "Handbook Flora of N.S.W." (1893), p. 81.

Hab.: Common in the "scrubs" (rain-forests) of the coastal area of Southern Queensland, at such places as Macpherson Range (National

Park), Tweed River, Tambourine Mountain, Mistake Range, Blackall Range, Gympie district, and Bunya Mountains. It extends into New South Wales.

From Moore's brief description and from dried specimens we had for some time been under the impression that his *F. Bellingeri* was identical with the earlier named *F. Watkinsiana* Bail., and recent opportunities of seeing living specimens of the New South Wales trees have confirmed this impression.

ORDER GRAMINEÆ.

Eragrostis amabilis Wight & Arn. in Hook. & Arn. Bot. Beech. Voy., 251. Not previously recorded for Australia.

Hab.: Kelsey Creek, Proserpine district. *Rev. N. Michael.*
Distribution: Tropical Asia.

Lophatherum gracile Brongn. in Duperr. Voy. Coq. Bot. 50, t. 8. Not previously recorded for Australia.

Hab.: Johnstone River, North Queensland. *Rev. N. Michael.*
Distribution: India, China, Japan, Malay, New Guinea.

On the Larval and Pupal Stages of Myzorhynchus bancrofti Giles, 1902.[1]

By L. E. Cooling, A.R.San.I.

(*Read before the Royal Society of Queensland, 26th Sept., 1921.*)

This Anopheline was described by Giles[2] in 1902, but hitherto the eggs, larvæ, and males have never been recognised.

On Thursday, 12th May, 1921, during an inspection of certain public health matters at some Chinese gardens in the vicinity of Mott street, Rifle Range, near Brisbane, it was deemed advisable to examine (for the presence of mosquito larvæ) the water of a creek hard by which was used by the Chinamen for irrigating purposes during protracted spells of droughty weather. The creek is in reality a tributary of Kedron Brook, and, after flowing a rather tortuous though short course, joins the Brook some 500 metres downstream.

The creek was more or less stagnant, forasmuch as an earthen dam had been thrown across the bed on the lower side, as Chinamen are wont to do. The water, though kept stagnant, was well aerated by an abundance of green Algæ and other aquatic vegetation. Manifestation of the oxygenation was to be had in the extraordinary numbers of small fish with which the water abounded, mostly of the species known as "Crimson-spotted Sun-Fish" and "Firetail" (*Rhombatractus fitzroyensis* Castelnau, and *Austrogobio galii* Ogilby, respectively). The excessive growth of vegetation had to a great extent rendered inert the activities of these mosquito-larvivorous fish, for

[1] Since having written this paper I find that I have fallen into the grave error of overlooking a remark by F. H. Taylor in his "Report for the Half-year ending December, 1914," made to the Institute of Tropical Medicine and published in the half-yearly reports from 1st July to 31st December, 1914, and from 1st January to 30th June, 1915, of that Institute. In a batch of mosquitoes collected by an expedition to Port Douglas, Taylor found "the male of *Myzorhynchus barbirostris* var. *bancrofti* . . ." *Cf.* p. 10 *l.c.*

[2] Giles: A Handbook of Gnats or Mosquitoes (2nd ed.), p. 511, 1902.

larvæ of *Nyssorhynchus annulipes* Walker were found in moderate numbers floating at the surface film and intercepted from the main body of water by a more or less unbroken layer of green Algæ.

After having scooped up many larvæ of other species, a specimen was noticed which bore, on examination with a hand-lens, certain characteristics which were at the time regarded as being peculiar to some hitherto unrecognised mosquito larva. It was carefully isolated from the others and its metamorphoses subsequently watched over with interest, for one would have naturally suspected the species under consideration; nor was this anticipation ill-grounded, insomuch that at the final ecdysis the desired imago appeared. Two hours were spent that day, during which time further supplies of the elusive species were sought for, but the collector frankly admits that he played the rôle of the unsuccessful sportsman and returned home with a spoil of three larvæ (last larval instar) and one pupa which ultimately gave rise to two females and one male of *Myzorhynchus bancrofti*. Since that time, no less than eight hours (extending into three days) have been devoted to the same spot, but the results were wholly disappointing, not one further specimen having been caught.

Metamorphoses.

On reaching home the same day (12th May) the specimens were transferred to a mosquito breeding cage.[3] Two days later the pupal ecdysis took place, resulting in a female specimen. On the third day one of the three larvæ had pupated and two days later the pupa gave rise to a female. One of the two remaining larvæ was killed for future use; the other eventually pupated, the pupal instar covering two days, and merged as a male specimen. The first of the two females which emerged died during the second day of aerial life without having sucked blood. The remaining female lived with a male four days, when the male died and was most unfortunately destroyed by ants before any microscopic observations could be made.

[3] The breeding cage takes the form of a parallelopiped of mosquito netting stretched over a wooden frame, about 8 by 8 by 14 inches. Small vessels of water containing larvæ are introduced into this mosquito cage by means of a sleeve in the side.

Habits of the Adult Female.—The surviving female, four days after the adult stage had been reached, commenced to bite when the bare arm was placed in the cage. After a short and decided selection of the site of puncture (back of the hand) about two minutes were occupied by haustellation; the female sucked so vigorously that hæmolysed blood (about 0·01 minim) was voided at the anus. This was examined as a blood-smear made on a slide under an oil-immersion lens; it revealed the presence of numerous leucocytes and plasmolysed erythrocytes. The bite produced a small white induration of the skin surrounded by a diffused erythematous patch, and a painful itching for some minutes followed. A period of four days elapsed before a second haustellation took place, and after a further interval of six days a third meal of blood was taken. Despite the fact that banana and jam were freely offered to the female, as well as a judicious supply of blood, the mosquito died on the sixth day after the third meal, having completed an aerial longevity of 21 days without ovipositing.

Macroscopic Appearance of Male.—Perhaps the most outstanding feature of the male is its relatively smaller size. With reference to the resting posture, it might be said that the body axis, when the insect is on a wall, forms an angle with the wall of 80 degrees; when on a horizontal plane the angle measures about 65 degrees.

LARVA.

Macroscopic Appearance and Behaviour.—A large, very dark larva, with very large and pronounced palmate hairs, the latter just discernible to unaided vision under the best illumination (incident obliquely). The chætotaxy is also rather distinctive. In the living condition, the larva skirts along the surface film of the water by bold lateral strokes of its whole body.

Characters as seen by an Aplanatic Hand-lens (× 20).—When the larva is held in a column of water by means of a pneumatic dropper and examined either by direct transmitted or reflected light, an excellent view of the palmate hairs is to be had. The chætotaxy may be studied *en masse*, but the individual structure of "hairs" can only be appreciated after having made microscopic observations of them.

Microscopic Structure.—The following descriptions are based on morphological observations made on two larval

exuviæ and an entire specimen, all dehydrated through the graduated alcohols and prepared as permanent microscopic mounts in Canada balsam. It might be added that very little variation was noticed in these three specimens and the characteristics to be noted present a striking constancy.

Length of larva exclusive of caudal chætæ, 7 mm.

Head and anal segment dark and heavily pigmented.

Head.—Head markedly narrower than thorax, mahogany coloured. Eyes roughly triangular in shape, existing merely as aggregations of undifferentiated pigment cells. Antennæ slightly curved, covered with many sharply pointed but simple spines the size of which latter decreases from base to apex. Proximal portion of antennæ slightly incrassated. A branched seta arises from a submedian point on the antenna, the branches being about 12 in number, of equal length and giving the appearance of a radial grouping. Each antenna is tipped with two stout spinelike processes, weakly chitinised, also with an extremely delicate branched seta of about five branches. Mouth-brushes consisting of moderately chitinised simple "hairs." Labrum clothed with minute slightly recurved and distally serrated setæ. Mandibles consisting of small but heavily chitinised "teeth." Labial plate roughly triangular, the base obtusely and symmetrically crenated; there are about three lateral, more or less irregular blunt teeth and a median (apical) one of average size. An asymmetrically shaped hole occurs on either side of the median line of the labial plate. The frontal "hairs" of the head exist as six well-defined branched setæ.

Thorax showing the usual divisions, rendered manifest by the pro-, meso-, and meta-thoracic branched setæ, the metathoracic tufts being the most defined and outstanding. In addition to this usual chætotaxic grouping, there is a group of three long simple hairs which arises from a moderately chitinised tubercle on the antero-lateral margins of the thorax; at the base of each of these hair-tufts are two unequal spines, one markedly chitinised, the other (longer one) weakly so. On the inner side of these hair-tufts are two minute, branched setæ, one on each side of the median line. There is a small but pronounced feathered hair on each side of the mesothorax and a smaller and less pronounced one on the antero-lateral aspect of the prothorax. Several *very* minute palmate hairs are to be found on the thorax.

Abdomen.—The abdominal segments 1 to 3 have branched lateral setæ rather much like those of the thorax; segments 4 to 6 with long bifid setæ. All the abdominal setæ arise from distinct chitinous tubercles, and in addition to the ordinary lateral setæ there are much smaller branched ones arising near their bases. The typical palmate hair takes the form of rather large and mottled sharply tapering "leaves," the edges of which can be observed to be minutely serrated only by close focussing of the fine adjustment when the iris diaphragm is reduced to a minute aperture; from 15 to 19 such "leaves" go to make up one of the large palmate "hairs." There are large palmate "hairs" on segments 3 to 7, minute ones (less notched) on segment 2, and still more minute ones on the thorax (2 pairs). The thoracic and abdominal palmate hairs show a gradual transition both in size and complexity, which is a good object lesson in the development of the typical "palm" from a simple "hair-tuft."

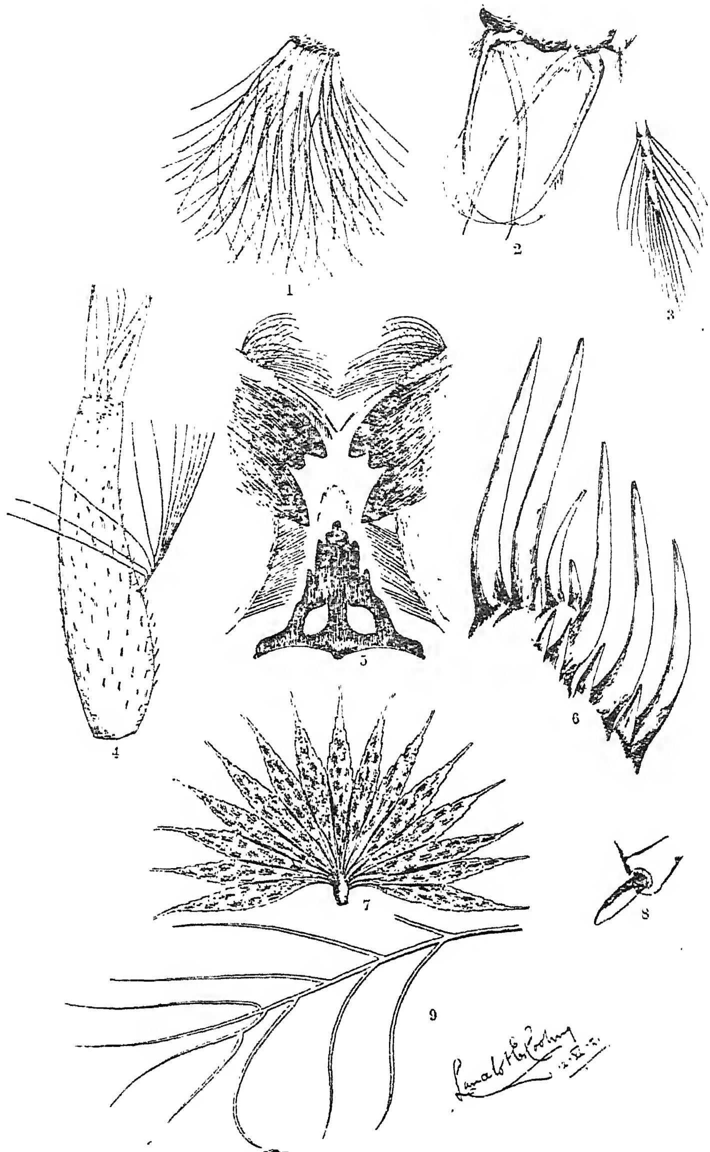
The spines of the comb on the eighth abdominal segment take the form of simple undifferentiated (except for size) spikes, large roughly alternating with smaller ones. The number is about 14 on either side.

The anal segment is of a mahogany colour, and its surface is invested with numerous minute sharp, simple spines, of about the same shape and size as those existing on the shafts of the antennæ. Ventral beard arranged in about 10 paired groups of typically branched hairs. Dorsal beard well represented. Swimming fans equal, moderately elongated and obtusely pointed.

PUPA.

Macroscopic Appearance and Behaviour.—The pupa of *M. bancrofti* presents nothing extraordinary except for its apparent uniform dark colour and large size. Its movements are rather sluggish.

Lens Characters.—A most striking feature of the pupa is the linear extensions of mottled or variegated colour-markings of the cephalothorax. What were, on the field, taken to be variegated scale-markings of a well-developed contained imago apparently showing through the diaphanous puparium, were, afterwards, by examining the exuvial puparium, undoubtedly due to chitinous incrassations of the pupal skin. When we reflect that it is more difficult to identify Culicid pupæ than



Myzorhynchus bancrofti.

Description of text-figures.—1, ventral beard of larva; 2, tail fin of pupa; 3, branched "hair," 7th abdominal segment of pupa; 4, antenna of larva; 5, mandibles and labial plate of larva (head viewed from a ventral position); 6, shape and disposition of spines of the lateral comb; 7, palmate hair; 8, chitinous "spur" on segments 2-6 of pupa; 9, distal portion of a branched "hair" (from one of the six frontal hairs of the head).

larvæ—in the writer's opinion, such as it is, an anomalous feature of descriptive biology, and if a crude analogy can be drawn, the converse of von Baer's great law of embryonic generalisation—then the pupa of *M. bancrofti* presents a notable distinction amongst the Culicidæ. The caudal fins are rather striking by reason of their relative diminutiveness. The fans are also closely approximated and do not show any tendency to lateral spreading.

Microscopic Structure.—The mottled stripes of the cephalothorax roughly correspond to the lines marked out by the wing venation and the forked cell markings are clearly seen. The breathing trumpets are small, broad and triangular. There is a pair of large tree-like plumes of much-branched setæ at the base of the cephalothorax.

On each of the sides of the abdominal segments 2 to 6 is a short stout bluntly pointed and strongly chitinised spur. Each segment has a pair of branched setæ, each of which branches from a short stalk into 5 more or less equal and regularly disposed "hairs." There are also minute bifid and trifid "hairs" on each segment. The seventh segment bears a pair of small plumes of peculiarly branched hairs on the posterior angles.

The "leaves" of the caudal fin are hyaline, each stiffened in the ordinary way by a midrib, which latter shows a double contour, is very faintly striated transversely, and weakly chitinised, but ending in a short, highly chitinised spur or "bristle."

Note on the Taxonomic Position of Myzorhynchus bancrofti.

Taylor (1911),[4] after having examined specimens of *M. bancrofti* in conjunction with those of *M. barbirostris* v. d. W. from Philippine Islands, came to the conclusion that the former should be classed as a variety of the latter; he evidently assumed that the older-described species should necessarily be the one of longer standing (in nature), but, even if there be grounds for the justification of this sort of reasoning, the present writer is of opinion that one should be careful in drawing conclusions on hasty premises, the more so when it is said that

[4] Taylor, F. H.: Report of the Australian Institute of Tropical Medicine, 1911.

Taylor was working with a species of which, except for the female, little else was known. He is further of opinion that, now we are in a position to compare larval forms of both mosquitoes, and having already made a comparison with the brief intelligence he could glean from Theobold's Monograph of the Culicidæ of the World (iii, p. 86), relating to larval *barbirostris*, there is every reason for rejecting Taylor's synonymy on the differences observed in frontal hairs (p. 18 *l.c.* fig. 4f) and palmate hairs alone. Theobold's descriptions are unfortunately too brief, nor has the writer been able to obtain any other literature on the subject of larval forms of *M. barbirostris*. Nevertheless, it is only reasonable to conclude on the transmutation hypothesis that, when obvious differences are manifested in two larvæ, the imagines resulting from these forms will be more or less different.

The Freshwater Fish Epidemics in Queensland Rivers.

By Professor T. Harvey Johnston, M.A., D.Sc., F.L.S.,

and

M. J. Bancroft, B.Sc., formerly Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(Read before the Royal Society of Queensland, 28th Nov., 1921.)

At irregular intervals very widespread and deadly epidemics have appeared amongst freshwater fish in Queensland rivers, more especially those in the western portions of the State. We have endeavoured to ascertain the cause of the mortality but have not as yet succeeded. The outbreaks occur usually in localities that are not readily accessible and moreover generally last for a short time. These facts, together with tardy arrival of information as to the presence of the malady in any particular district, have prevented either of us from being present during an actual outbreak, though on one occasion a visit was paid to a locality just as an epidemic had subsided.

Since one of us has now left the State and the other has undertaken additional duties, it seems unlikely that either will be able, for some time at least, to give further attention to the matter now under consideration. We have therefore thought it advisable to bring together the information which we have collected, so that it may form a basis for some future worker.

We take this opportunity to express our indebtedness to the following for their kind assistance :—Mr. W. Hamilton, Chief Inspector of Fisheries, Brisbane ; Mr. R. Caldwell (Charleville) ; Messrs. M. J. Bergin (Goondiwindi), W. H. Ryan (Charleville), J. McKinley (Goondiwindi), and J. Hogan (Inglewood) of the Police Department ; Messrs H. A. Longman and J. D. Ogilby, Queensland Museum ; Messrs. F. Mills, T. Woulfe, and members of the Longreach Shire Council ; R. Varney (Brisbane) ; A. V. Stretton (Rankine River) ; J. F. Colbert (Lake Nash) ; W. H. Rudd (Austral Downs) ; the last-mentioned three localities being situated in the Northern

Territory. We are also indebted to the Commonwealth Bureau of Meteorology for furnishing full particulars regarding temperatures and rainfall recorded at various Queensland stations.

A preliminary report was published in 1917 by the senior author, but the information and material then available were very scanty. In that report it was regarded as likely that, prolonged dry weather having converted the rivers into a chain of stagnant waterholes, an unhealthy environment for fish had been created, such leading to weakness which gave the fungus *Saprolegnia* an opportunity to exchange its saprophytic life for a parasitic mode of existence, the invasion of the gills leading to death. Decomposing fish would cause a still further reduction of the oxygen supply and thus aggravate the condition. It was believed that the arrival of good rains would remove the stagnation, improve the aeration of the water, and establish a suitable environment for healthy fish life (Johnston, 1917, p. 131).

OCCURRENCE OF EPIDEMICS ALREADY RECORDED.

1892.—An officer of the Fisheries Department, N.S.W., mentioned the occurrence in 1892 of an epidemic causing mortality among fish in a tributary of the Barcoo near Lammermoor Station, in the vicinity of Winton, Queensland (Johnston, 1917, p. 126). A Longreach resident (Mr. Coleman) informed us that a similar outbreak happened in the Thomson River in that year.

No other record of such an occurrence was made until 1917, when widespread mortality appeared among the fishes of the western rivers of Queensland, while milder outbreaks occurred in certain rivers in the south-eastern portion of this State.

1917.—In July, Mr. F. Mills, Clerk of Longreach Shire, reported that fish were dying in the Thomson River and that similar conditions prevailed right out to the MacKinley River, nearly all species being affected.

In August of the same year Mr. A. Sugden sent down a catfish (*Neosilurus hyrtlii* Steind.), taken from the Bulloo River near Quilpie, and reported that fish were dying in large numbers in that river, and that similar conditions had occurred in Cooper's Creek.

In August and September 1917, Dr J. S. Elkington saw

fish (perch and catfish) floating down the Brisbane River. Mr. C. Booker reported that during the same months a widespread mortality had occurred among the fish in Wide Bay Creek and Mary River.

In the September number of the "Scientific Australian" (1917, p. 17) there appeared the following paragraph :—

"Mr. C. A. Baker writes from Kapunda that the proposed trip from Adelaide to the Gulf (of Carpentaria), which was to start on 17th of this month, has now been postponed until the end of March next year for the following reasons :—

"Mr. Kidman has been advised by some of his back-station managers that a most extraordinary and unique fish epidemic has occurred in the following rivers :—Diamantina, Bulloo, Cooper's Creek, and Wilson Creek. The fish have died in such quantities that the water in these rivers has become so polluted that it is not only unfit for human consumption but also for stock. The most extraordinary thing about the death of the fish in these rivers is that the epidemic has occurred in rivers, the headquarters of which are remote from each other and have different sheds and exits."

THOMSON RIVER, COOPER'S CREEK SYSTEM OF DRAINAGE.

Information regarding the earlier outbreak at Longreach (1917) is contained in the previous report (Johnston, 1917).

Early in April 1918 a letter, dated 30th March 1918, was received from Mr. F. Mills stating that fish were again dying in the Thomson River in the neighbourhood of that town. The following notes are taken from his letter :—

The river was in high flood during the months of January and February of this year and large numbers of fish were to be seen after the floods, apparently in a healthy condition but seemed to have a most voracious appetite as plenty were caught with the least of trouble. *The river was still running strong and there was no stagnant water in this locality*[1] as was the case during the previous epidemic. The fish principally affected were what are commonly known as yellow-belly, black bream, bony bream, and perch. They came to the surface of the water in an inert state, suddenly appeared to

[1] Italics ours.

take a fit and swam towards the shallow water or bank of the river, where they died. Their eyes bulged out and they appeared to be sightless. Inside the mouth was of a bluish colour. Their gills and scales appeared to be normal. The fish upon being opened up were found to be very fat. Neither the jewfish nor the freshwater tortoises, which were plentiful in the river, were affected. The epidemic, which commenced shortly after the heavy rains, was still present at the time of writing, *i.e.*, for a period of from three to four weeks. On 22nd March this outbreak was reported in the "Brisbane Courier."

On 23rd April Mr. Mills again wrote reporting that the mortality was not so pronounced and that difficulty had been experienced in obtaining for us a fish in the moribund state. Eventually a specimen, identified by Mr. J. D. Ogilby as *Therapon carbo* Ogilby & McCulloch, was sent down.

In the middle of May a rise in the river was occasioned by rains up country, sweeping away all signs of the outbreak, which had apparently lasted for almost two months, being at its height at the end of March.

On 7th August Mr. Mills informed us that the mortality had reappeared at the end of July, fish dying in large numbers. The senior author was away from town at the time and the junior author was not able to arrive at Longreach until 17th August. On the following day, although prolonged search was made up and down the large lagoon adjacent to the town, only two moribund fish were obtained, one being a *Therapon hillii* Castln., the other a bony bream, *Nematalosa elongata* Macleay. Dead and rotting fish were exceedingly abundant, especially at the lower end of the lagoon, where they were piled up against the crossing. Although close search was made, no more dying fish were obtained. On several days hauls were made with a small-meshed net in the hope of obtaining diseased specimens. An astonishingly large number of fish were caught in each haul but none appeared diseased, so the majority were returned to the water, a few being kept for examination. Three species, *Plectroplites ambiguus* Richardson (golden perch or yellow-belly), *Therapon hillii* ("black bream" or grunter), and *Nematalosa elongata* (slender bony bream) were by far the most abundant. No catfish were caught in these hauls.

During the week previous to the 18th, men had been mployed raking the fish out of the river and burning them.

Heaps of fish could be seen along the bank for about two miles. A large proportion of those seen in the unburnt heaps were small jewfish (resembling *Neosilurus*), but specimens of black bream, golden perch, and bony bream could also be recognised. The mortality apparently had affected old and young fish alike, as large and small specimens of perch and bream were found.

Flocks of water-birds had also assisted in clearing the river of dying fish. Cormorants (*Phalacrocorax sulcirostris* and *P. melanoleucus*), snake-birds (*Plotus novæhollandiæ*), white egrets (*Herodias timoriensis*), blue cranes (*Notophoyx novæhollandiæ*), nankeen herons—so-called bitterns (*Nycticorax caledonicus*)—and kites (*Milvus affinis*) were all present in large numbers. Black ibis (*Plegadis falcinellus*) and white ibis (*Ibis molucca*) were also numerous, but pelicans (*Pelecanus conspicillatus*), though present, were not common. In the upper reaches of the lagoon wild pigs had been seen feeding on the dead fish.

Mr. W. Woulfe wrote from Longreach (26th December 1918) stating that the epidemic had reappeared in the Thomson River, affecting chiefly fish of from four to six pounds in weight. He counted 111 dead fish that morning along a length of only fifty yards of the bank. Cormorants were present in countless thousands, while pelicans, herons, blue cranes, &c., were in great numbers.

In the "Courier" of 7th January, 1919, it was stated that during the preceding three weeks great mortality of fish had occurred in the Thomson River, deaths being more numerous than on the previous occasion, large fish especially being the victims.

As an outbreak was reported in the Brisbane daily press (27th August 1919) as having occurred in the Bulloo and Wilson Rivers, we wrote to Mr. Mills who informed us that the epidemic had broken out at Longreach during the winter and had lasted about six weeks, terminating in early August.

McINTYRE AND SEVERN RIVERS.

Through the kindness of Mr. W. Hamilton, Fisheries Department, Brisbane, we had access to reports from the police officers at Goondiwindi (Messrs. M. J. Bergin, J. McKinley) and Inglewood (Mr. J. Hogan) relating to an epidemic during the late winter of 1918 in these two rivers.

Mr. Hogan reported (10th August 1918) that large numbers of fish, principally jewfish and golden perch, had died recently in the McIntyre and Severn (Dumaresq) Rivers, the outbreak being locally regarded as due to one or other of the following :—(1) intense cold and continual heavy frosts destroying fish, especially in shallow water ; (2) the prevalence of a disease ; (3) the low state of the river. Death of the fish was not due to the use of dynamite though this had been put forward as a possible explanation.

Mr. Bergin reported (7th August) that dead fish were coming down the river past Bengalla Station. On 28th August he kindly forwarded to us additional information. The McIntyre River had been rather dry and stagnant, as little rain had fallen from Christmas 1917 until August 1918, when rain caused a fresh in the river and the epidemic ceased. Murray cod, yellow-belly, and jewfish were especially affected, and diseased specimens were all found to be fat. During his ten years' residence in the district he had only once previously noted a similar epidemic, viz., during the great drought of 1915. He also stated that he remembered fish dying in the Condamine River some years ago, but believed that it was due in that particular case to the pollution of the water by an adjacent wool-scour.[2]

Mr. J. McKinley referred (2nd September 1918) to the mortality in the McIntyre in the Goondiwindi district affecting chiefly the Murray cod and golden perch, mainly small specimens. Such fish when opened were found to be very fat, though otherwise they looked normal. Since the recent heavy rains the disease had disappeared.

BURNETT RIVER.

In July 1918 fish died in the lagoon at the junction of the Nogoa and Burnett Rivers. When visited by Dr. T. L. Bancroft some weeks later only a few dead fish were to be seen and these were all in the shallow water.

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[2] H. B. Ward has drawn attention to the effect of industrial wastes on fish life in his paper on "The Elimination of Stream Pollution in New York State" (Trans. Amer. Fisheries Soc. 48. 1918, pp. 1-25). *See also* Shelford 1917, 1918a, 1918b, 1919a; Shelford and Powers 1919; Hofer 1906, pp. 83-86.

BULLOO RIVER.

On 4th September 1918 a paragraph appeared in the Brisbane "Daily Mail" announcing that a mysterious disease was attacking fish in the Bulloo River from Adavale to the vicinity of Toompine, where they were dying in countless numbers, rendering the water unfit for human consumption. A local theory attributed the disease to the extraordinary season and to overbreeding.

The Commissioner of Police was approached on this matter, and communicated with one of his officials in the Bulloo district to find out whether the epidemic had ceased. Subsequently the text of Sub-inspector W. H. Ryan's reply and, later, a copy of his report (dated 12th Sep ember, 1918) on the matter were forwarded. This officer stated that some weeks previously the fish had been dying in great numbers in the Bulloo, but since then rain had fallen in places and as a result of the fresh in the river the mortality had ceased. All species of fish in the stagnant waterholes were affected but golden perch appeared most susceptible, being the first to die. It was considered locally that the mortality was caused by lack of oxygen in the stagnant water. It was noticed at Quilpie that fish were not killed in Hoodrum Lake, though this contained Bulloo River water and was only a short distance from the smaller stagnant river-waterholes where fish were dying in hundreds.

In the "Daily Mail" of 27th August 1919, mention was made that the epidemic had reappeared in the Bulloo and in the Wilson River, fish of three pounds and upwards dying in extraordinary numbers, smaller specimens apparently escaping the disease.

GEORGINA AND DIAMANTINA RIVERS.

In the Brisbane "Daily Mail" of 14th September 1918, the observations of Mr. E. R. Caldwell on the condition of fish in the Georgina River were given. Evidences of an epidemic were first seen by him in the Georgina near Lake Nash (Northern Territory), but on following the river southward dead fish could be seen piled up along the banks. Mr. Ogilby had suggested this might be due to the salmon disease which affected fish when the water was low. There were many large pools in the Georgina, however, and no sign of contaminating influence, the only places in which fish were not dying being the "kopai"

(mineralised) holes. All kinds of fish were affected and in each case the disease showed the same symptoms—"a blue spot on the side, upon the bursting of which the fish died." Mr. Ogilby subsequently supplied information to the Press that *Saprolegnia* would not live in water which contained any degree of salinity, as was the case with the "kopai" holes.

Mr. Caldwell informed us that the epidemic had appeared in November 1917 and June and July 1918, in the upper reaches of the Georgina, in the vicinity of Lake Nash. Tons of dead fish were to be seen and plenty of sick fish were being caught near the surface and along the edge of the lake by aboriginals. The species represented were yellow-bellies, catfish (jewfish), bony bream, and another kind. The stretch of water in which the mortality occurred was five or six miles long and in places between 20 and 30 feet in depth. Commonly associated with the disease was the presence on attacked fish of a bluish swelling about the size of a sixpence or shilling, at the side in the abdominal region, the aboriginals stating that when these "boils" burst the fish turn over and die. In "kopai" holes the water was clear and brackish owing to abundance of calcium sulphate ("kopai") and the fish were normal, whereas in the adjacent waterholes containing clayey or muddy water, even though somewhat brackish, the fish were dying. This happened between May and September 1918 while Mr. Caldwell was on the Georgina. There was no drought at the time and cattle were fat.

Mr. Caldwell also stated that in large waterholes in the Austral Downs district (Northern Territory) near Camooweal, though fish were plentiful, no dead ones were seen by him during his visit in May 1918.

In subsequent communications (October and November 1919) he informed us that attacked fish came to the surface and were very sluggish in their movements. An old aboriginal had informed him that fish had died periodically in the Georgina River as long as he could remember. Mr. Caldwell stated that one view as to the cause was that it was due to overstocking and consequent shortage of food; another, that it was due to cold weather, or to the prevalence of "umbrella grass" which blocked up the gills of the fish. Cormorants were especially abundant, and these, together with the large numbers of pelicans present, were in his opinion sufficient to prevent any overstocking.

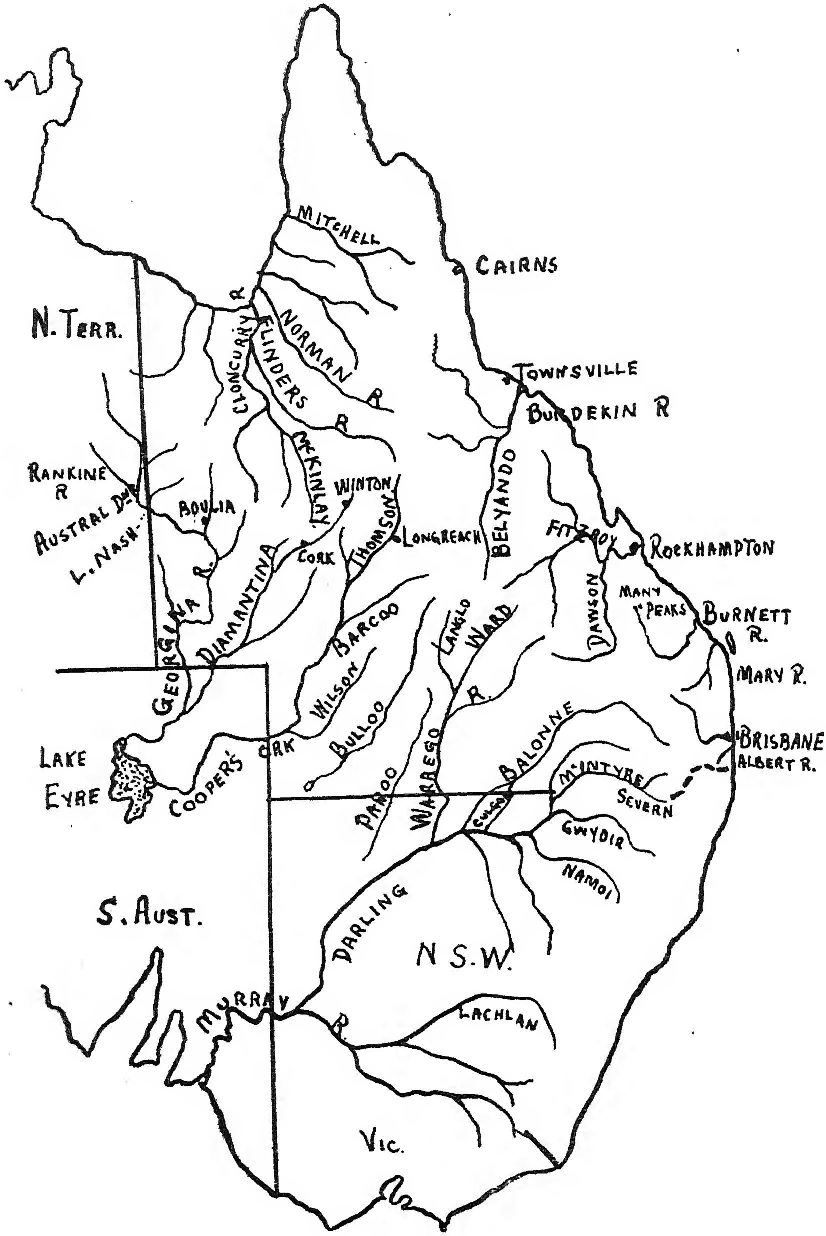
Mr. J. F. Colbert, of Lake Nash Station, Northern Territory, in reply to a series of questions, gave the following information (September-November 1919). He had met with the epidemic on the Diamantina. Bourke, and Georgina Rivers, especially during June and July. In these rivers and particularly at Lake Nash and at Boulia (Bourke River), the dead fish were at times piled up on the banks by the wind, forming a mass some feet across, and this in spite of the presence of enormous numbers of water-birds which were engaged in devouring them. The chief kinds affected were yellow-belly, bream, and perch. The bluish "boil" mentioned by Mr. Caldwell was not observed. Diseased specimens were fat. He was unaware whether there was any relation between the occurrence of the epidemic and drought or cold. The water was not obviously mineralised, and bore-water was not present at Lake Nash. The disease, which appeared and disappeared suddenly, was found both in shallow and in deep holes containing water which was of a dark-green colour—"as green as a typical duck-pond"—whereas during the time that the epidemic was not present it was muddy or milky. In places, *e.g.* Old Cork Station (Diamantina), the stench from the decomposing fish was so bad that people had to leave the homestead and camp elsewhere. The epidemic did not make its appearance at Lake Nash during 1919. Mr. Colbert questioned large numbers of aboriginals, who believed that the death of the fish was brought about by one of two causes:—(*a*) the water turned green and killed them; (*b*) the fish fought and killed each other. The latter is obviously an insufficient explanation.

Mr. W. H. Rudd, Austral Downs, Northern Territory, stated (January 1920), in reply to our questions, that he had observed the condition in the Georgina and Diamantina Rivers during September, October, and November 1917, and in the former river during the latter half of 1918. It was not seen during 1919. Yellow-bellies and a kind of catfish were especially affected, becoming drowsy, swimming slowly near the banks in shallow water, and then floating and dying on the surface. Though the fish were fat and appeared to be somewhat swollen, no discolouration was noticed. The epidemic appeared each time rather suddenly about midwinter, finally disappearing when the rivers began to flow as a result of heavy rainfall. Though it occurred during the dry time of the year, there was no drought, but there were very cold periods with ice on the water occasionally. Good rains had fallen each

year prior to the outbreak. Fish died chiefly in the large waterholes. The water was described as good; though not clear it was not muddy, and as far as Mr. Rudd knew it contained very little mineral matter. No bore-water entered the holes where the epidemic occurred, and weeds were not obvious. He mentioned that some local people thought that overstocking was the cause, but stated that bird life was as plentiful as during the period when the epidemic was not prevalent. The aboriginals informed him that they had never known fish to die in such quantities before and believed that the cold weather was the cause. In places blacks were employed to drag the dead fish out of the waterholes with wire-netting, the water having become too polluted to be used for drinking. Sick fish were eaten by the blacks without apparent ill effect.

Mr. A. V. Stretton, who is in charge of the police station at Rankine River, wrote on 31st July 1920 regarding the outbreaks at Anthony's Lagoon (Northern Territory) where he was previously stationed. From his replies to questions submitted to him, the following information has been taken. The fish affected were chiefly perch (*Plectroplites*), only a few catfish being among them. They could be readily caught by hand when near the water's edge. All were very fat. A noticeable feature in regard to affected catfish was the presence of a red streak along the abdomen. Though the fish were slightly swollen, the bluish colour referred to by some of the previously reported observers was not noticed. He stated that they began to die at the lagoon on 10th August 1917, destruction proceeding for eleven days, the fish dying in "countless thousands." On 20th March 1918 the epidemic reappeared in spite of the fact that the river was running, and continued until 12th April, a period of about 23 days. There was another outbreak on 16th July 1918, lasting nine days. There had not been any further occurrence up to the time that Mr. Stretton had left the locality.

The epidemic appeared and disappeared suddenly, and in his opinion had no relation to drought. Though no rain fell during the periods when the mortality was in evidence, yet there had been abundant rainfall in 1917 and 1918—viz., 32 and 30 inches respectively, whereas the annual average was only 18 inches. There was no relation to abnormally cold weather, as the temperatures during the winter were not noticeably lower than during other years. The water was not charged


N. TERR.
MITCHELL
CAIRNS
TOWNSVILLE
BURDEKIN R
NORMAN R
FLINDERS R
CLONCURRY R
McKINLAY
WINTON
RANKINE R
AUSTRAL Dn
L. NASH
BOULIA
THOMSON
LONGREACH
BELYANDO
FITZROY
ROCKHAMPTON
CORK
DIAMANTINA
GEORGINA R
BARCOO
DAWSON
MANY PEAKS
BURNETT R.
MARY R.
LANGLO
WARD R.
WILSON
BULLOO
BALONNE
BRISBANE
ALBERT R.
LAKE EYRE
COOPER'S CRK
McINTYRE
SEVERN
PAROO
WARREGO
CULGOA
GWYDIR
NAMOI
S. AUST.
DARLING
N.S.W.
MURRAY R.
LACHLAN
VIC.

with mineral. Artesian bore water did not enter the creeks. All permanent waterholes were affected irrespective of depth. The colour of the water during the epidemic was milky or muddy, which was the normal appearance in the district.

He concurred in the opinion generally held in the locality that the cause of the mortality was "overstocking," since fish were present in enormous numbers in the rivers and creeks. Birds such as ibises, spoonbills, pelicans, jabirus, herons, cormorants, were extremely abundant at the time.

Owing to the amount of pollution which had occurred, Mr. Stre ton forwarded a sample of the water to the Health Department, Darwin, with a view to ascertaining whether it was fit for human consumption. The report of the analysis is referred to later.

WARREGO RIVER.

Mr. Caldwell, in a letter to the Brisbane "Daily Mail" of 7th December 1918, stated that, though the epidemic was in evidence in the more northerly situated rivers in this State, it had not appeared in the Warrego and its tributaries, *e.g.* Langlo and Ward Rivers, during 1918, whereas it had caused heavy mortality in these rivers during 1918. He mentioned the current belief that it was due to overstocking in stagnant pools, and stated that though fish might be dying in the main streams, yet in the billabongs or lagoons only a short distance away, and fed by the flood-waters of these streams, fish life was healthy and plentiful.

He informed us by letter dated November 1919 that he had been told that the epidemic had made its appearance in the Warrego River near Cunnamulla and that the decomposing fish were constituting a nuisance to the townspeople (October). Conditions were hot and very dry, stock dying from drought. At Dillalah, also on the Warrego but some distance to the north, a very large waterhole was at the time apparently free from the disease.

OTHER LOCALITIES.

Mr. R. Varney reported (April 1920) that he had observed the epidemic amongst yellow-bellies and black bream, particularly in the muddy water of lagoons in the Longreach and Winton districts, during very dry weather in 1918 and 1919. The condition was noticed in the Cork Lagoon near Winton late in 1919. [Thomson and Diamantina Rivers.]

He also gave an account of some other observations. The heavy thunderstorm which ended the long drought in 1902 caused an enormous quantity of vegetable débris, dead leaves and grass, to come down Enoggera Creek, Brisbane, this forming a blanket about six inches in thickness covering the surface. Fish, mainly mullet, died in hundreds but only a few eels seem to have been affected. Although the water was clear and the bottom was sandy and rocky, the fish, he believed, had been suffocated.

In midwinter 1909 very cold weather was experienced in the Mount Tambourine district, and large numbers of mullet were killed in the Albert River. He believed this to have been due to poisoning by the Moreton Bay chestnut, since large numbers of these trees which were growing along the banks were killed by the cold, their leaves and fruit falling into the water.

He also mentioned that at Cania, 80 miles west of Many Peaks, large numbers of fish—chiefly bony bream and mullet—came to the surface of the water in Three Moon Creek (a tributary of the Upper Burnett) and died, as did also the eels which fed on them. In this case the water was clear and running over a sandy and rocky bottom with plenty of weed present. He believed the occurrence to be due to some form of poisoning.

We are not in a position to comment on any of these three occurrences, which appear to be isolated.

It will thus be seen that during 1917 and 1918 fish epidemics occurred in many rivers widely remote from one another and belonging to different drainage systems. It is reported that an outbreak occurred in July 1917 at McKinley on a tributary of the Cloncurry, itself a tributary of the Flinders, flowing into the Gulf of Carpentaria. This is the northernmost locality known to us. The most seriously affected was that system of rivers which flow inland towards Lake Eyre—the Georgina, Eyre's Creek, the Diamantina, Cooper's Creek or Barcoo with its tributaries, the Thomson and Wilson Creeks. All exhibited the same phenomena at one time or another. Four outbreaks have been recorded from the Thomson. The mortality occurred during the winter of each year in the Bulloo, another inland river. An epidemic was reported in July 1918

in the Severn (Dumaresq) and McIntyre Rivers on the southern border of Queensland. These rivers form part of the Barwon or Darling River system. Three rivers flowing east from the Great Dividing Range were affected though not very seriously—viz., the Brisbane and Mary in the winter of 1917 and the Burnett in 1918.

We may note that the outstanding features of the epidemic were as follows :—

(*a*) The species especially affected were the golden perch or yellow-belly (*Plectroplites ambiguus*), the freshwater black bream or grunters (*Therapon* spp.), Murray cod or perch (*Oligorus macquariæ*), and bony bream (*Nematalosa elongata*), and jew-fish or catfish (various species of *Siluridæ*).

(*b*) It usually occurred during the colder and drier portion of the year, July and August, though sometimes earlier and often persisting later.

(*c*) The water was nearly always stagnant and the epidemic ceased suddenly, after heavy rains had caused the rivers to flow.

(*d*) The affected fish were always fat ; they became lethargic, swam slowly at the surface of the water, and died. A bluish colour was commonly seen in the mouth region.

POSSIBLE CAUSES.

1. The use of dynamite or other explosive.

2. Climatic—
   (*a*) Dry weather ;
   (*b*) Low temperature.

3. State of the water—
   (*a*) Physically, *i.e.* presence of suspended matter or weeds which might clog fish-gills ;
   (*b*) Chemically, *e.g.* excess of carbon dioxide, deficiency of oxygen, acidity or alkalinity, etc.

4. Poisoning due to the presence of some toxic substance in the water.

5. Overstocking and consequent starvation.

6. Disease caused by parasites which may be—
   (*a*) Helminths,
   (*b*) Protozoa—
      (i.) Myxosporidia,
      (ii.) Flagellata, Infusoria,
   (*c*) Fungi,
   (*d*) Bacteria.
7. Two or more of the foregoing acting at the same time.

(1) DYNAMITE THEORY.

It has been suggested that the use of dynamite as an illegal means for obtaining fish might be an explanation of the widespread mortality.

The reports from the Severn and McIntyre Rivers are opposed to such an opinion. We think that the presence of dead fish floating down the Brisbane River in 1918 was, at least in part if not entirely, due to this cause. Specimens from the locality submitted to us by Mr. H. A. Longman, Director of the Queensland Museum, were found to have the swim-bladder burst and the viscera disorganised, an effect such as one might expect from the use of some high explosive.

Mr. Ogilby of the Queensland Museum, in a letter to the Brisbane "Sunday Times" of 18th September 1918, referred to the matter and stated definitely that boating parties in the vicinity of Ipswich were in the habit of using dynamite, and since they probably obtained not more than one in five of the fish killed by the explosion the remainder would float downstream, such fish as perch (*Sciæna australis*), sea mullet (*Mugil* spp.), and catfish (*Tandanus* and *Neosilurus*) being recognised. Mayer[3] has recently referred to the effects of high explosives on fish, especially on those possessing a swim-bladder.

We believe that we may then rule out the Brisbane River reports regarding the epidemic, but there is no justification for attributing the widespread mortality elsewhere to this cause.

(2) EFFECT OF CLIMATE.

This should be treated under two headings—(*a*) the influence of dry weather and (*b*) the effect of temperature—but we have not sufficient data to allow us to consider them separately.

[3] A. G. Mayer, Yearbook, Carnegie Institution 1917, No. 16 pp 185-6; abstract in J.R.M.S., 1919 (3), p. 239.

Queensland is a country in which heavy rain normally falls during the summer, December to April, while the winters are dry. Thus cold and dry conditions commonly go together, although in the early summer the weather may be hot and dry.

The Commonwealth Meteorologist, in a letter dated 31st January 1918, drew our attention to the following statement by Mr. J. B. Henderson, Government Analyst, Brisbane, in a report on a sample of water from Cooper's Creek at Windorah :—

"With reference to your letter . . . and sample of water, no poisons were found in the water. A small fish placed in the water for 48 hours was quite normal at the end of that time.

"The enormous number of dead fish referred to in your letter points either to suffocation by mud or to a more common cause, a sudden drop in temperature. Nothing in your letter indicates or contra-indicates the presence of either of these causes."

The Meteorologist went on to state that an investigation of the temperature records for June 1917 showed rather remarkable departures from the normal and appeared to bear out Mr. Henderson's theory. A copy of minima records for a number of inland stations in Queensland was enclosed.

The localities were Urandangie, Boulia, Winton, Longreach, Isisford, Windorah, Tambo, Adavale, Thargomindah, and Cunnamulla. From the 1st to the 15th of that month there was a warm period in which the averages of daily minimum temperatures for the fifteen days and the number of degrees *above* June normal—given in brackets—for each locality were as follows, respectively :—52·3 (6·8) ; 51·2 (6·5) ; 51·3 (1·6) ; 50·5 (2·8) ; 48·4 (1·4) ; 48·8 (4·0) ; 47·2 (3·8) ; 49·5 (5·7) ; 50·0 (4·9) ; 49·4 (7·2). During the remainder of the month there was a sudden drop experienced at all these stations, commencing on 16th June. The mean of the daily minima during the cold period and the number of degrees *below* the June normal, for each of the ten localities were respectively as follows :—37·8 (7·7) ; 38·6 (7·1) ; 40·5 (9·2) ; 38·2 (9·5) ; 37·9 (9·1) ; 35·8 (9·0) ; 32·6 (10·8) ; 35·3 (8·5) ; 38·5 (6·6) ; 38·0 (4·2). The mean of daily minima for June 1917 at each locality as compared with the normal (calculated from twelve years' records) were given as follows :—45·1 (45·5) ; 44·9 (45·7) ; 45·9 (49·7) ; 44·4 (47·7) ; 43·2 (47·0) ; 42·3 (44·8) ; 39·9 (43·4) ; 42·4 (43·8) ; 42·2 (45·1) ; 43·7 (42·2).

Thanks to the kindness of the Commonwealth Meteorologist we have been able to attempt the correlation of weather records and outbreaks of the epidemic.

Detailed climatological data from several localities for certain specified months were supplied and the following particulars have been abstracted and presented for convenience of reference in tabular form :—

1. The average minimum for the month for all years in which records were taken, *i.e.* the normal minimum.
2. The minimum recorded for the actual month under review.
3. The mean of the minima for that month.
4. The average of total rainfall (in points) for the month for previous years.
5. The actual rainfall recorded for the month.

—	1917.				1918.				
	June.	July.	Aug.	Sept.	Mar.	June.	July.	Aug.	Sept.
				THOMSON RIVER, LONGREACH.					
1	47·1	45·9	46·8	55·0	66·3	46·8	45·2	46·9	..
2	32·2	35·5	32·2	39·4	51·0	35·2	27·0	37·0	36·0
3	44·4	44·8	47·0	53·8	61·6	44·5	40·9	47·5	49·4
4	88	81	32	58	237	85	78	32	..
5	21	4	149	193	97	0	0	51	0
				BULLOO RIVER, ADAVALE.					
1	43·5	42·3	43·3	52·0	..	43·1	41·5	43·8	..
2	30·8	31·5	32·2	36·8	..	31·2	26·1	34·2	26·0
3	42·4	42·2	44·4	51·5	..	41·2	36·7	46·0	49·4
4	121	74	55	64	..	117	73	57	..
5	88	25	91	167	..	15	. 32	91	0
				BULLOO RIVER, THARGOMINDAH.					
1	45·0	42·1	44·8	50·6	..	45·0	42·0	45·0	50·5
2	33·0	37·5	35·0	39·0	..	34·1	31·0	40·3	39·1
3	44·2	44·6	45·5	51·2	..	44·0	40·4	48·9	49·8
4	84	51	56	50	..	82	51	59	49
5	90	27	6	75	..	0	85	164	0
				McINTYRE RIVER, GOONDIWINDI.					
1	43·7	41·1	42·1	48·7	..	43·3	40·6	42·4	48·6
2	28·4	29·0	30·8	34·2	..	27·8	23·2	37·2	39·0
3	40·5	39·8	42·4	49·8	..	39·1	35·4	46·3	47·5
4	178	179	133	162	..	174	177	136	159
5	113	77	64	440	..	22	94	252	15
				MARY RIVER, GYMPIE.					
1	46·0	43·9	44·1	52·2	..	45·1	42·9	44·7	51·6
2	29·0	29·0	31·0	33·0	..	30·0	29·5	39·0	35·2
3	42·4	39·9	46·8	50·4	..	40·8	38·1	47·6	48·8
4	252	218	193	218	..	247	214	194	219
5	56	114	175	363	..	2	39	215	295

(i) *Thomson River.*—Longreach records for 1917 shew that June and July of that year were both colder and drier than in the average year (2·7° and 67 points less for June; 1·1° and 77 points less for July). An outbreak occurred in July. The lowest minima recorded during June and July were 32·2° on 22nd June and 35·5 on 5th July. Thus, although both months were colder and drier than usual, the thermometer reached freezing point only once. We are not aware of the condition of the river prior to the outbreak.

The outbreak which occurred in March 1918 can scarcely have had any dependence on the temperature. The records again shew that it was colder (by 4·7°) and drier (140 points less) than the average, but the lowest minimum recorded was only 51°, viz., on 18th March.

The rainy season had begun early in November 1917. The Thomson was in high flood during part of January and February 1918, and was still running when the outbreak began in March (*vide* Mr. Mill's letter of 30th March), there being no stagnant water at the time.

June 1918 was again colder and drier (2·3° and 85 points less) than the average, while the lowest minimum (35·2°) occurred on the 28th. In July, however, a more decided cold snap was experienced; for the nine days following 8th July the minimum records were consistently low, culminating in three nights of frost—28·5° on the 15th, 27° (lowest recorded) on the 16th, and 31·7° on the 17th. After this no further frosts were experienced.

No rain fell in the district during May, June, or July, so that the river was fairly low when the outbreak began at the end of July. The epidemic was at its height during the first week in August and had abated completely by the middle of the third week. Showers of rain yielding 45 points fell on 3rd and 4th of August. During September 1918 no rain fell. The minimum temperature fell to 36° on the 5th, this being the lowest for the month, though the three succeeding days experienced low minima.

An outbreak occurred during the latter half of December 1918, extending into early January 1919 (midsummer), when the temperatures were certainly not low. It was a very dry period and the water was stagnant. Another made its appearance in July and early August 1919, but particulars as to the weather are not in our possession.

(ii) *Bulloo River.*—Weather records for Adavale shew that June and July 1917 were drier and colder than the normal, being, however, only very slightly colder for July. The outbreak was reported in August but probably began in July. June 1918 was again colder and drier than normal. The epidemic began about the end of July and ceased after a fresh had occurred in the river in August. It reappeared in August 1919.

(iii) *McIntyre River.*—With regard to the epidemic occurring in the McIntyre and Severn Rivers during July and August 1918, the records shew that during June and July both minimum and rainfall records were considerably below the normal. The river was very low until rain fell in August.

(iv) *Mary River.*—Gympie weather records shew that June 1917 was colder and drier, and July 1917 much colder and drier, than the normal. An epidemic was reported to have occurred in the Mary River in August and September of that year.

June and July 1918 were both still colder and drier than in the preceding year, but no epidemic followed.

(v) *Burnett River.*—For the last ten days of June 1918 and the first eighteen days of July frosts were experienced practically every night (twenty nights) at Eidsvold. We are indebted to Dr. T. L. Bancroft for allowing us to use his records.

(vi) *Georgina and Diamantina Rivers.*—The outbreaks took place in September, October, and November 1917 and from June to September 1918, but none occurred during 1919. Though the epidemic made its appearance during the dry weather, conditions were not those of drought. Many local people thought that cold was the cause of the trouble.

From the foregoing it will appear that cold is not a necessary factor though it was a very common concomitant. Neither is drought a necessary condition, though dry weather appeared to be common to nearly all the outbreaks.

One can, however, state that dry cold conditions, and especially abnormally dry weather, favour the epidemic, and that the advent of sufficient rain to set the rivers in motion terminates it.

Heath (1883) found that certain species of fish were able to survive after having been frozen in blocks of ice for a few

hours, provided they were slowly thawed out. Bumpus (1898) suggested that the heavy mortality of tile-fish off Florida in 1878 might be due to a sudden diminution of temperature as a result of an alteration of the Gulf Stream. Hofer, in his valuable work on fish diseases (1906, pp. 87-93), gave an account of the effects of cold on the skin of freshwater fish in Europe.

Wells, in one of his many papers dealing with the relation of fish to their environment, stated that many species can detect and react to temperature differences as small as 1 to 2 degrees Centigrade (1913, p. 339). Next year he published a paper giving an account of his investigations regarding the resistance and reactions to temperature (1914). He found that, in the case of freshwater fish, the degree of resistance varied with the species and with the size of the individual, large specimens being more resistant to high temperatures than small fish of the same species, while small individuals were able to adapt themselves more successfully to sudden changes from warm to cold. He also reported that in no case did death result from sudden change from a higher to a lower temperature, though the widest range—viz., from the maximum for the species down to freezing point—was tried. He admitted that it was possible that a sudden and great lowering of temperature might cause death in the case of certain species. His experiments showed that fish can detect and react to variations of temperature amounting to only 0·1 degree Centigrade.

Shelford and Powers (1915, p. 325) ascertained that marine fish were capable of detecting differences of ·5° to ·6° C., and probably as low as ·2° C.

3. STATE OF THE WATER.

This may be considered under various headings—viz., alterations in regard to amount of suspended matter or weeds, the amount of gases (oxygen and carbon dioxide) present, in the degree of alkalinity or acidity, and in the amount of salts in solution.

(*a*) SUSPENDED MATTER.

We know that the amount of suspended matter in stagnant pools depends mainly on the chemical composition of the water, since the presence of certain substances leads to the precipitation of finely divided and colloidal material. One might draw attention to the muddy water of a stream and the clear water of adjacent "kopai" holes rich in sulphate of lime.

Under this heading one may refer to the presence of organisms, whether plant or animal, which could act mechanically by interfering with the passage of water through the fish-gills.

Reference was made to the suggestion that overgrowth of water-weeds, including "umbrella grass," might cause trouble. It is to be pointed out that weeds grow only under certain conditions of light, depth, etc., and in the case of rooted plants form only a fringe around deep lagoons. Some of the waterholes in which the epidemic occurred were many miles long and up to 30 or more feet in maximum depth, the greater part of the lagoons being too deep for rooted plant growth. Abundance of green water-vegetation improves aeration, though one must admit that organic decomposition results in the using up of oxygen and the liberation of carbon dioxide and other gases. Moreover, the presence of abundant decomposing matter is associated with abundance of saprophytic and saprozoic organisms—*e.g.* fungi, bacteria, and certain protozoa—all of which are using up oxygen instead of liberating it.

Mr. Colbert referred to the deep-green colour of the water in his locality, Lake Nash, during the periods in which the fish epidemic occurred. The colour suggests that phytoflagellates were present in enormous numbers. It is not impossible that they might set up some irritation of the gills and become entangled in the mucus produced, and thus lead to partial or complete suffocation. But the presence of this intense colouration does not seem to have been a constant feature of the outbreaks, and suggests to us that the stagnant conditions allowed the organisms to grow at a much more rapid rate than they were being devoured by the various other organisms present. As a rapid decomposition of these might cause the liberation of toxic substances, the matter will be referred to later, under the heading of poisons as possible causes.

(*b*) Effect of Alterations in Chemical Composition of Water.

An analysis of samples of Longreach water, one from the Thomson River and the other from an adjacent billabong, was made by the Government Analyst, Mr. J. B. Henderson,

his report to the Longreach Shire Council, dated 29th August 1918, being as follows :—

——	(1) From River.	(2) From Billabong.
Odor	Earthy and fœtid	Same but much more pronounced
Total solids	41·0	36·8 parts per 100,000
Chlorine	2·0	2·0
Alkalinity	6·0	6·0
Sulphates	2·1	2·1
Nitrates as nitrogen	·048	trace
Free ammonia	·01	·044
Albuminoid ammonia	·06	·094
Oxygen consumed in 15 minutes at 90° F.	·281	·462
Oxygen consumed in 4 hours at 90° F.	·536	·782
Hardness	5·5	5·5

The samples are highly contaminated with organic matter and are unfit for drinking.

We do not know what was the composition of the water from either situation during periods when the epidemic was not present.

When discussing the above analysis of the Longreach water with Mr. Henderson, he informed us that the sample was milky and was taken at a time when the Thomson River was covered with dead or dying fish, the water being then green and stagnant. He said that the results relating to the presence of ammonia were of no value as ndicating the constituents of the original sample. The amount of total solids was distinctly low and the organic matter unduly high.

On the occasion of our visit the water in the billabong was found to be very darkly coloured, with a greenish tint, apparently on account of an exaggerated growth of algæ. The escape of fat or oil from the mass of decomposing fish present caused the water to be fœtid and to possess a greasy feel. Ciliates and flagellates were in abundance, as were tiny crustaceans.

A report on a sample of water from Anthony's Lagoon, Northern Territory, sent by Mr. Stretton to the Health Department, Darwin, during the 1918 epidemic, was issued by Mr. M. A. Kelly for the Chief Health Officer, and contained the following information :—Colour, dirty greenish white ; odour,

sulphuretted hydrogen; reaction, none, neither acid nor alkaline; residue on evaporation, ash and a slight charring; free ammonia in considerable amount; chlorides, equivalent to 16 grs. per gallon; sodium chloride 26·3 grs. per gallon; hardness, 8 degrees of temporary hardness; nitrates, none; metallic impurities—iron, strong trace; zinc, lead, copper, and arsenic absent; oxygen absorbed in 15 minutes at 212° F., 1·30 grs. per gallon; microscopic examination, grass and weeds in all stages of putrefaction; bacteriological examination, innumerable colonies.

These last two findings might have been expected owing to the time which would necessarily elapse between the collecting of the sample and its examination. The analysis suggests that the sample originally contained a considerable amount of organic matter.

Marsh (1908, p. 905-6) has pointed out that there is as yet no sure method of determining by chemical tests whether water is suitable for fish-life. The ordinary "sanitary analysis" determines whether water is fit for drinking and for domestic use, but water which may be passed as suitable for such purpose may kill fish in a short time, and we know that fish can thrive in waters which on routine examination would be pronounced unfit for human use. Both Marsh (1908) and Shelford (1918c, p. 39 footnote) point out that, in this connection, it is important that such additional items as acidity or alkalinity, the amount of hydrogen sulphide, carbonaceous material capable of being utilised as food, unusual metals, dissolved air, etc., should be known.

The most important items in the above analyses seem to be those relating to the amounts of oxygen and carbon dioxide present. The blue colour inside the mouths of affected fishes suggests a deficient oxygenation of the blood, and this may be due either to a diminished amount of oxygen or to a greatly increased amount of carbon dioxide, or to both.

Wells (1913) has studied the resistance of fishes to different concentrations and combinations of oxygen and carbon dioxide. In regard to the latter he pointed (p. 329) out that the presence of a high and low concentration of CO_2 is affected by many factors, such as the amount of vegetation in the water, character of the surrounding soil and incoming water, depth of water, season of the year, daily temperature, animals present,

amount of decaying organic matter, rainfall, and exposure of the surface to winds. Hence great variation may occur within the same body of water at different times. He stated (p. 344) that small variations (*e.g.* 5 to 10 cc. CO_2 per litre) from the normal in regard to the amount of CO_2 present apparently produce ultimately effects similar to those caused by greater variations (25 cc. CO_2 per litre) in relatively short periods. Certain species are more sensitive than others in this respect and would therefore react first—*i.e.* they would endeavour to move away from the adverse conditions. Resistance comes into play when organisms cannot move away from unsuitable surroundings but must adapt themselves to the unfavourable environment. We know that fish are able to withstand stagnant water during dry seasons by gulping air at the surface. We also know that some fish are less affected than others. Wells found—(1) that the presence of oxygen in large amounts (10 cc. per litre) counteracted the detrimental effect of high CO_2 content (50 cc. per litre); (2) that low oxygen content (0·1 cc. per litre) in alkaline water caused death sooner than when it occurred in slightly acid water; (3) that the resistance of fishes to fatal concentrations and combinations of oxygen and carbon dioxide varied with the individual, with the species, and with the weight, small fish being more resistant per unit weight than were large ones.

Wells (1916) investigated the seasonal resistance of fishes in the United States, and stated that as a result of several years' observations i had been noted that in nature their resistance to detrimental factors in general was lowest in late summer (July to October) and highest in spring (February to May or June). They were found to be least resistant just after the breeding season.

Shelford and Allee had previously (1913) pointed out that young fish were more sensitive to changes in regard to the amounts of these two gases than older fish were, and that some species reacted to a concentration of CO_2 as low as 5 to 7 cc. per litre, and of oxygen as high as ·7 to 1 cc. per litre.

Powers (1914) found that freshwater crayfishes reacted to very weak concentrations of CO_2.

Wells (1918) stated that at a concentration of 10 cc. per litre CO_2 soon proved fatal to more sensitive species, and that it was doubtful if there were any freshwater fish which could

continue to live in water where the CO_2 content averaged as high as 6 cc. per litre throughout the year, but that it was still to be demonstrated whether there were any species of truly freshwater fish which could reproduce successfully in water that was decidedly alkaline to phenolphthalein throughout the year. Shelford (1918c, pp. 45-6) pointed out that since CO_2 results from the decomposition of organic matter, in the process of which oxygen is consumed, so the presence of any large quantity of CO_2 nearly always indicates a lack of oxygen. He thinks it probable that the CO_2 content should not average more than 3 cc. per litre over breeding grounds, and more than 6 cc. per litre during the summer, as such quantities are not usually accompanied by lack of oxygen. He suggested that the amount of CO_2 might be taken as an index of the suitability of the water for fish-life.[4] Wells (1915) found that the CO_2 optimum for the various species of freshwater fish experimented upon under summer conditions varied from the acid side of neutrality to 6 cc. per litre. Marine fish behaved differently as they preferred slight alkalinity to acidity (Shelford and Powers, 1915; Shelford 1918c, p. 40; 1919). The time taken to kill freshwater fish, using higher concentrations of acid, was found by Wells to be proportional to the hydrogen ion concentration.[5] This author gave considerable attention to the reactions of fish to the ions of H and OH.[6]

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[4] *See also* Birge and Juday (1914, pp. 583-7) regarding the distribution of CO_2 in lakes. *Also* Shelford, 1918c, pp. 40-1; 1914.

[5] "The theory of solution explains acidity in water by the occurrence of hydrogen ions, formed from dissolved electrolytes, in excess of hydroxyl ions; and alkalinity by a similar excess of hydroxyl over hydrogen ions. Neutrality is, then, the condition when, as in pure water, the two concentrations are equal." (L. J. Henderson, The fitness of the environment. MacMillan, New York, 1913, p. 142.)

[6] By titration, using phenolphthalein and methyl orange as indicators, Wells (1915) determined the amount of CO_2 present in a fixed condition (as carbonates), "half bound" (*i.e.* bicarbonates), and free (as CO_2), since methyl orange remains unaffected by carbonic acid so that the bases present as carbonates or bicarbonates can be titrated with an acid; while carbonates are alkaline to phenolphthalein, bicarbonates neutral, and free CO_2 acid. Methyl orange is very sensitive to OH ion whereas the latter indicator reacts to the H ion instead and consequently gives an acid reaction with CO_2. In the presence of CO_2, methyl orange will give an alkaline reaction though the water may still be acid owing to the presence of a higher concentration of H than OH ion.—*See also* Shelford, 1919b.

Distilled water has been shown to be toxic to various organisms owing to its influence on the permeability of the gill membranes, leading to the loss of salts by the animal and the absorption of water by osmosis (Abbot, 1913). Such water was found by Wells (1915, pp. 241, 254) to be not toxic if rendered slightly acid, but remained so if made slightly alkaline.

The following extract from Wells's paper (1915, pp. 243-4) is of interest :—" The fact that in natural bodies of water the chemical reactions of the water may vary from alkalinity through neutrality to acidity, or the reverse, makes he practical importance of a knowledge of the reactions and resistance of fishes and other organisms to such chemical conditions an obvious one. From the experiments (referred to in his paper) it is clear that water which gives an alkaline reaction to phenolphthalein for any length of time during the year is undesirable as a home for most freshwater fishes. On the other hand, marine fishes with the exception of anadromous species would probably not survive in water which was even faintly acid. Since algæ or other phytoplancton forms may cause a body of water to become wholly or partly alkaline, through their ability to dissociate the bicarbonates, vegetation in fish waters assumes a line of importance heretofore little considered. The effects of sewage upon the acidity or alkalinity of natural bodies of water must be reconsidered in the light of its possible injurious or beneficial effects due to its chemical action. . . . Henderson's work (1913)[7] on the mechanism which maintains a constant proportion of H and OH ions in the blood of animals, suggests the physiological reason for this extreme sensitiveness of the fishes. Very small variations in the proportions of these two ions in the blood of the organism are of grave importance and we find in the blood a combination of gases and salts that makes such variations impossible as long as the animal is normal. The blood will maintain its normal chemical reaction (just on the alkaline side of neutrality) in the face of relatively large changes in the environment, yet we know that the mechanism breaks down when the change is either too gr at or too long continued. . . . The hypersensitiveness of the animals to the chemical reaction of the water in the case of aquatic organisms is another important factor in preserving the normal reaction of the blood, as the reactions

[7] L. J. Henderson, The fitness of environment. McMillan, New York, 1913.

of the organisms work in a way that causes them to turn back from concentrations of H and OH ions that would be detrimental. . . . The physiological effect of the acid, neutral, and alkaline water upon the organism very probably has to do with decrease or increase in the permeability of the exposed tissue cells (especially the gills in the case of fishes)." Alkalinity increased and acidity at first caused a decrease in permeability, but acidity if increased caused an increase in permeability, so that, as in the case of alkalinity, death was ultimately the result. In regard to marine fishes the results of Shelford and Powers indicated that the action of alkaline water produced a normal permeability of the membranes, and it is likely that an acid condition of the water would kill such fish by diminishing the permeability (Wells, 1915, p. 245).

As already stated, the appearance of the affected Queensland fish suggested suffocation, while the bulging of the eyes noted by some observers strengthens the suggestion that the water contained excess of carbon dioxide.[8]

Carbon monoxide is very poisonous to freshwater fish (Shelford, 1917). Wells (1918, p. 562) ascertained that a concentration of from 75 to 100 cc. per litre CO_2 would be required to produce as deadly results as 1 cc. per litre CO, and that a saturated solution of CO in water did not lose its toxic effects even after two weeks' exposure to the air (p. 563).

Another gas which is formed as a result of organic decomposition, and may be added to water supplies as a result of pollution by industrial waste, is sulphuretted hydrogen. Shelford and Powers (1915; Shelford, 1918b) drew attention to the extreme sensitiveness of fish to this gas, as they endeavoured to avoid the presence of even a fraction of a cubic centimetre per litre. Fish died in a few minutes in water containing 7·6 cc. H_2S per litre, and a combination of this gas with CO_2 was reported to be "exceedingly deadly." "Since decomposition yields CO_2 and consumes oxygen and is accompanied by the production of hydrogen sulphide which is also accompanied by the consumption of oxygen, it is reasonable to suppose that on a bottom from which vegetation is absent and decomposition actively takes place, a fatal combination of lack of oxygen and presence of hydrogen sulphide and probably

[8] For references to "pop-eye" of fishes *see* C. C. Farr, Rep. Austr. Assoc. Adv. Sci. 13, 1911 (1912), p. 354; Ogilby and McCulloch, Mem. Q'land Museum, 5, 1916, p. 112.

carbon dioxide can quickly develop" (Shelford and Powers, 1915, p. 322). No doubt, in the case of the Queensland epidemics H_2S has played an important rôle in aggravating the condition, though it probably did not cause it in the first place.

Ammonia is very toxic to fish and is apparently not recognised by them, as they do not react in such a way as to avoid it when given the opportunity (Wells, 1915a).

The reactions and resistance of fishes in their natural environment to salts were studied by Wells (1915b), who used the chlorides, nitrates, and sulphates of the commoner bases—*e.g.* sodium, ammonium, potassium, calcium, and magnesium.[9] He found—(1) that freshwater fish reacted to their presence in solution but were not as sensitive to salt ions as to H and OH ions; (2) that they reacted to combinations of antagonistic salts or salt and acids in a manner which tended to bring them into a region of optimum stimulation; and (3) that rhythmic alterations in metabolic activity in the case of anadromous fish (such as salmon) were correlated with their migrations.

Powers (1917) has studied the relative toxicity of the chlorides and nitrates of the alkalies and alkaline earths, as well as various other substances, on goldfish. He pointed out that it is improbable that toxicity of a substance is due to osmotic pressure.

Reduction in salinity as a result of flood-waters being turned aside to cover certain Japanese reefs[10] led to very great destruction of marine algæ and the associated fauna.

4. Poisons as a Possible Cause of the Epidemic.

Apart from the toxic effects likely to be caused by the agencies referred to in the last section, one can probably dismiss the possibility of the mortality being caused by a poison—*e.g.* one of plant or mineral origin—on account of the wide area involved, the different flora in each region, the different types of water, and the character of the outbreaks.

[9] Whetmore (1918) in his investigations regarding the epidemic amongst wild ducks in Utah, U.S.A., proved that it was due to alkali poisoning, especially by the chlorides of calcium and magnesium which are brought to the surface of the soil of the swamps by capillary attraction.

[10] Yendo, Econ. Proc. Roy. Dublin Soc., 2, 1914, pp. 105-122 (not available). *See also* papers by Sumner (Bull. Bur. Fisheries 25, 1905 (1906) pp. 53-108) and Scott (Id. 28, 1908 (1910), pp. 1145-1150) regarding the effects on the blood of fishes of changes in salinity and density of water.

In a report Mr. J. B. Henderson stated that toxic effects were not produced by a sample of the water in which the epidemic had occurred, when a fish was kept in it for 48 hours. It should be pointed out, however, that all species are not equally susceptible, and that it was possible that gaseous poisons, if such were the cause, may have escaped or have become altered.

The possibility of some toxic substance being liberated as a result of decomposition of myriads of dinoflagellates has been mentioned. It is known that certain phytoflagellates, especially *Peridinium*, *Gonyaulax*, and allied forms, have caused very serious epidemics amongst various organisms, the result being brought about by the death of immense numbers of these tiny organisms, the decomposition products destroying fish, molluscs, etc., In fact, such water, which is generally coloured reddish by these flagellates, is often spoken of as "poison water." The animals so killed, on decomposing, aggravate the condition so that widespread mortality has been caused.

In the "Sydney Morning Herald" of 27th December 1918, attention was drawn to the "red weed pest" destroying fish and oysters owing to its extraordinary abundance in Port Macquarie, N.S.W. Mr. A. H. Lucas[11] described this dull-red seaweed as *Falkenbergia olens*. He stated that it probably lived on plants in deeper water, being brought inshore in great masses at irregular intervals, sometimes collecting on oyster-beds with disastrous results, owing to its rapid decomposition and putrefaction, a great deal of gas being evolved.

Hedley (1915, p. 29) referred to two sudden and widespread epidemics which occurred amongst sedentary intertidal organisms in Port Jackson in 1866 and 1891. In regard to the latter Whitelegge (1891) reported that immense numbers of the dinoflagellate *Glenodinium rubrum* caused the clogging of the gills of various molluscs and led to their death and ultimately, through their decomposition, to the destruction of great numbers of other organisms.

Other accounts of heavy mortality amongst marine fish, caused by flagellates, have been published by Torrey, 1902 [*Gonyaulax*—Californian Coast in 1901]; Gilchrist, 1914 [*Noctiluca*, *Peridinium*—South Africa]; Hornell, 1917 [Eugle-

[11] A. H. Lucas, Notes on Australian Marine Algæ, P.L.S. N.S.W., 44, 1919 (pp. 175-6).

noids—South India]; Nishikawa, 1901 [*Gonyaulax*—Japan]. Taylor (1917) rejects these as being a likely cause of certain epidemics in Florida waters, one being previously reported by Ingersoll (1882).

5. OVERSTOCKING.

Overstocking is commonly regarded as being the cause. Owing to dry weather, the rivers and waterholes shrink considerably, and as a consequence there is much less water and food for the fish which come to occupy the restricted areas. It seems likely that overstocking may be a contributing factor to the epidemic. The increased number of fish would use up more food and oxygen and liberate more CO_2, which would lead to ill effects unless there were increased plant activity to preserve the balance and so prevent the water from becoming more and more acid. Besides, should the real cause of the epidemic be some protozoan, fungoid, or bacterial organism, then the greater density of the fish population would be favourable to the rapid spread of the disease.

6. PARASITISM AS A POSSIBLE CAUSE.

It is well known that organisms may cause serious epidemics. Animal parasites likely to be incriminated may be (*a*) Helminths, and (*b*) Protozoa such as (i) Sporozoa (Myxosporidia and Microsporidia), or (ii) Flagellates, perhaps Ciliates. Amongst plant parasites one must consider (*c*) Fungi and (*d*) Bacteria.

(A) Helminth Infection.

The cyanosed appearance of infected fish suggested the possibility of gill parasites, especially Heterocotylean Trematodes, being a cause, through their interference with normal gill function. It is known that infection is sometimes extremely heavy, and Ward (1918, p. 374) has stated that *Gyrodactylus* may be in sufficient numbers to cause death. McCallum (1915, p. 410) has reported that infestation by *Diplectanum* may be so intense as to bring about the death of its host. Pratt (1919, p. 2) has also referred to gill-infesting trematodes as a cause of considerable mortality, especially in enclosed bodies of water. Magath (1917, p. 59) in a paper dealing with a fluke, *Lissorchis*, which was regarded as causing heavy losses amongst certain fish in Iowa, U.S.A., mentioned that some parasites so weaken their hosts that the latter may die from some cause which would otherwise not have so affected them.

A careful examination of a considerable number of affected and healthy fish, chiefly from the Thomson River, revealed the presence of many species of Gyrodactyloid trematodes infesting the gills in both cases, so that invasion by the minute parasites can at most be only a contributing factor and not the cause of the outbreaks.

Though an examination of the viscera revealed the presence of digenetic trematodes, various nematodes and echinorhynchs, as well as occasional cestode larvæ, none of these can be incriminated. The marked fatty degeneration of the viscera has already been mentioned.

(B) Protozoa as a Cause.

(i) *Sporozoa.*

Of the Sporozoa the most important groups in the present connection are the Myxosporidia and the Microsporidia. It is well known that some species give rise to epidemics amongst freshwater fish, while many produce lesions resulting in the death of the host, though an epidemic may not follow. The best known is *Myxobolus pfeifferi* Thel., which at times brings about a tremendous destruction of barbels in the Moselle, Rhine, Meuse, Marne, Aisne, and Seine. Full accounts of this Myxoboliasis are given by Hofer (1906, p. 71) and Gurley (1894, p. 227), in whose works further references to literature are to be found. The fatty degeneration which takes place as a result of that disease reminds one somewhat of the condition commonly associated with the Australian outbreaks, but the "boil formation" so common in the barbel disease is not manifested in our epidemics. Though some observers have referred to the presence of a bluish swelling on the under side of affected fish, it is not a constant feature and is certainly not of the type associated with the European epidemics. A disintegration of muscular tissue of fish is also caused by certain other Sporozoa—*e.g.* some species of *Chloromyxum* and *Glugea* (*G. destruens* Thel.).

Though some of the diseased fish first examined by us were found to be parasitized by Myxosporidia, belonging to the genera *Myxobolus*, *Myxosoma*, *Myxidium*, and *Henneguya*, and occurring in various organs such as the gills, gall-bladder, and kidneys, yet a search through healthy material showed the

presence of similar organisms, so they may be disregarded as direct causes of the mortality. Those met with have been already described by us (J. & B. 1918).

Lymphosporidium truttæ, a member of the Haplosporidia and a parasite of the lymph system, was described by Calkins (1900) as a cause of an epidemic amongst trout. (*See also* Hofer, p. 60 ; Doflein, p. 934.) Another member of this Sporozoon group, *Ichthyosporidium* sp., near *I. gasterophilum* Caull. & Mesnil, has been recorded by Robertson (1909) as fatal to sea-trout.

(ii) *Protozoa—Infusoria and Flagellata.*

The chief ciliate parasites harmful to freshwater fish are *Ichthyophthirius*, *Chilodon*, and *Cyclochæta*. The first-named causes epidemics in aquaria (Hofer, pp. 122-7). The other two appear to be of less importance.

Of the Flagellata, *Costia* is said to cause at times heavy mortality amongst salmon fry in Austria (Franke, 1910 ; Hofer, p. 115).

None of these protozoa except an occasional *Cyclochæta* was detected during our examinations of Queensland material, whether diseased or not.

(c) Fungi as a Possible Cause.

As a result of our examination of fish dead or dying from the disease, we found the fungus *Saprolegnia* constantly present, either on the general body-surface (including fins and tail) or on the gills, or even on both situations. A similar finding was reported by one of us (Johnston, 1917) when dealing with a specimen previously sent down. In addition to the records of Australian occurrences contained in that paper, there is a short one by Waite (1894), who mentioned finding the fungus on *Ctenolates ambiguus* Richdsn. (= *Plectroplites*). Further references to the disease and to literature relating to it can be found in papers by Hofer (1906), Clinton (1893), and Johnston (1917).

It was previously regarded as the cause of the salmon disease, but it is now recognised that the fungus is secondary and is capable of readily exchanging a saprophytic mode of existence for a parasitic one, should it have an opportunity. Such would be given by injuries as well as by the presence of external conditions or diseases which interfere with normal

healthy fish-life. Bacterial maladies of fish are commonly associated with *Saprolegnia* attack, and Shelford (1918c, p. 46) has stated that excessive acidity due to CO_2 probably favours the development of this destructive fungus.

(D) Bacteria as a Possible Cause.

Almost the whole of the diseased material was already dead at the time of our examination, and as putrefactive changes had taken place a bacterial exploration under field conditions would probably have been of little value. Though bacteria were found in various tissues, the possibility of a bacterial disease being the cause of the epidemic had not been provided for by us, and as a consequence cultures were not able to be made on the occasion of our only visit to a locality in which the epidemic was present.

Several bacterial diseases of fish are known, the most destructive being probably that which has at different times caused heavy mortality amongst salmon. The so-called "salmon disease," which was formerly attributed to *Saprolegnia*, has been shown by J. H. Patterson in his Parliamentary Report, Fishery Board for Scotland (1903), to be due to a diplobacillus, *Bacillus salmonis pestis*. Additional information was given by Drew (1909). [*See also* Hofer, pp. 19-22]. Marsh had previously (1902, 1904) described *Bacterium truttæ*, a pleomorphic organism, sometimes assuming the form of a coccus, or a bacillus, or a diplobacillus, which was found to be fatal to various kinds of trout in the United States.

Hofer (1906) gave a summarised account of the various bacterial diseases described as occurring in freshwater fish in Central Europe, the causative organisms being *Bacillus salmonicida*, *B. pestis astaci*, *B. cyprinicida*, *B. anguillarum*, *B. vulgaris*, *B. piscicidus*, *B. piscicidus agilis*, and a few others.

Grieg Smith (1900a) described one as *B. piscicidus bipolaris*, which was found to be fatal to certain marine fish in New South Wales; and also another (1900b) called by him *Vibrio bresimæ*, which destroyed marine bream in that State.

7. IS IT DUE TO MORE THAN ONE CAUSE?

The epidemic nature of the Queensland disease, the apparently rapid course which it runs, and the particular susceptibility of certain species, all suggest that the malady is

of bacterial origin, and that various local and climatic conditions favour it. We then offer the suggestion that the epidemic may be due to a high acidity on account of excess of CO_2 in stagnant water, favouring the spread of a virulent bacterial disease amongst the weakened fish. The presence of *Saprolegnia* aggravates the condition, as probably also does hydrogen sulphide, which is itself a decomposition product resulting from the effects of the disease.

SUMMARY.

A very destructive epidemic makes its appearance amongst freshwater fish in Queensland and Northern Territory at very irregular intervals, usually during dry and cold conditions, ceasing when the rivers run freely. The affected streams belong to various watersheds—*e.g.*, Lake Eyre basin (Cooper's Creek, Diamantina, Georgina, Thomson, and Wilson Rivers); Bulloo River; Warrego River; Darling system (McIntyre and Severn Rivers); Flinders system (McKinley River); Burnett. It is apparently not due to the following :—Use of explosives; dry weather; low temperature; overstocking; animal parasites (helminth or protozoon).

It is suggested that the prime cause will be found to be a bacterial organism, whose spread is favoured by a high acidity of the water due to excess of CO_2. The presence of the fungus *Saprolegnia* aggravates the disease, as no doubt does hydrogen sulphide also.

ADDENDUM.

Dr. J. Shirley informed us that a series of epidemics causing considerable mortality occurred in the Logan River, in South-eastern Queensland, during the drought years just prior to 1902, but further information regarding these outbreaks is not yet available.

Mr. W. B. Alexander supplied us with the following statement which is of interest. Early in July 1921 a steamer arrived at Fremantle with its hold on fire, and large quantities of water were pumped into it. Among the cargo was a consignment of cyanide for the Kalgoorlie mines, which partly dissolved and entered the harbour water, causing the death of a large number of fish belonging to many different species. The occurrence was reported in the Perth daily Press.

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THE

ROYAL SOCIETY OF QUEENSLAND.

ABSTRACT OF PROCEEDINCS.

REPORT OF COUNCIL FOR 1920.

To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting its Report for the year 1920.

During the year eleven papers were read before the Society and published. In addition the following lectures were delivered:—"Petroleum in Queensland," by Mr. J. B. Henderson, F.I.C.; "The Origin of Petroleum," Mr. W. H. Bryan, M.Sc.; "The Einstein Theory," Professor H. J. Priestley, M.A.; "The Hawaiian Islands," Professor H. C. Richards, D.Sc.; and "The Czecho-Slovakia Republic," Dr. J. V. Danes (Consul-General for Czecho-Slovakia).

On the occasion of the visit of the Prince of Wales an address was presented to His Royal Highness by the President on behalf of the Society.

An event of scientific significance during the year was the Pan-Pacific Conference held at Honolulu in August. The Society was represented by Professor H. C. Richards, D.Sc.

The Society is again indebted to the Queensland Government for a vote of £50 towards the publication of scientific papers. It is also indebted to the Trustees of the Walter and Eliza Hall Fund for defraying part of the cost of publication of the following papers by Professor T. Harvey Johnston and Miss M. J. Bancroft (Walter and Eliza Hall Fellow in Economic Biology): "Notes on the Chalcid Parasites of Muscoid Flies in Australia," "Experiments with Certain Diptera as Possible Transmitters of Bovine *Onchocerciasis*," "The Life History of *Habronema* in relation to *Musca domestica* and Native Flies in Queensland," "Notes on the Life History of Certain Queensland Flies"

There have been nine meetings of the Council, the attendances being as follows:—F. B. Smith (President) 8, W. H. Bryan 4, F. Butler-Wood 4, B. Dunstan 4, W. D. Francis 9, E. H. Gurney 5, T. H. Johnston 2 (granted leave of absence), H. A. Longman 6, H. C. Richards 6, J. Shirley 8, C. T. White 8.

The roll of members consists of ten corresponding and ninety-one ordinary members. During the year eight new members were admitted and three resignations were accepted.

Since the last annual meeting the deaths of Sir Hamilton Goold-Adams, late Governor of Queensland and Patron of the Society, and of Sir S. W. Griffith, late Chief Justice of Australia and a life member of the Society, have occurred. Letters expressing the sympathy of the Society were forwarded to the relatives of the deceased in each instance.

To the University of Queensland our thanks are tendered for affording accommodation for meetings and for housing the library.

The Financial Statement for the past year shows a credit balance of £101 10s. 8d., but against this there is a printer's bill amounting to £111 4s.

F. B. SMITH, *President.*

W. D. FRANCIS, *Hon. Secretary.*

The Royal Society of Queensland.

Cr. BALANCE SHEET for Year ending 31st December, 1920. Dr.

Receipts.

	£	s.	d.
By Bank Balance	68	7	4
Government Subsidy	50	0	0
University Subsidy to Papers	25	0	0
Extra Copies of Papers	9	9	3
Sale of Paper	0	1	1
Subscriptions	120	15	0
	£273	12	8

Expenditure.

	£	s.	d.
Insurance	0	18	0
Hon. Secretary (Postage and Petty Cash)	10	1	6
Hon. Librarian	2	0	0
Hon. Treasurer (Postage) 1919	0	14	7
Hon. Treasurer (Postage) 1920	1	1	0
Typewriting	1	1	0
Printing (Pole and Co.)	155	11	4
Bank Charges	0	10	0
Exchange	0	1	0
Stamps	0	1	1
Deficiency in Subscription	0	2	6
Total	172	2	0
Balance	101	10	8
	£273	12	8

Examined and found correct.
(Signed) H. J. PRIESTLEY, 1st March, 1921,
Hon. Auditor.

JOHN SHIRLEY, Hon. Treasurer

The Printers' Account for Vol. XXXII (£111 4s.) is not included.

ABSTRACT OF PROCEEDINGS, 30TH MARCH, 1921.

The Annual General Meeting of the Royal Society was held on Wednesday, 30th March, 1921, at 8 p.m., in the Geology Lecture Theatre of the University.

Mr. F. B. Smith, B.Sc., F.I.C., President, in the chair.

The President referred to the return of Professor T. Harvey Johnston from America and Europe.

The minutes of the previous Annual General Meeting were read and confirmed.

The Annual Report of the Council and the Financial Statement were adopted on the motion of Dr. J. Shirley, seconded by Mr. E. H. Gurney.

The following officers were elected for 1921 :—

President : C. T. White, F.L.S.

Vice-Presidents : F. B. Smith, B.Sc., F.I.C. (*ex officio*) ; Professor H. J. Priestley, M.A.

Hon. Treasurer : Dr. J. Shirley, F.M.S.

Hon. Secretary : W. D. Francis.

Hon. Editor : H. A. Longman, F.L.S.

Hon. Librarian : W. H. Bryan, M.Sc.

Members of Council : E. W. Bick, B. Dunstan, E. H. Gurney, Prof. T. H. Johnston, M.A., D.Sc., Prof. H. C. Richards, D.Sc.

Mr. C. R. Morton was elected an ordinary member.

The congratulations of the Society were tendered to Mr. W. E. Cameron, B.A., on his appointment as Consulting Geologist to the Federated Malay States.

The newly elected President was installed and returned thanks for his election.

The retiring President delivered his address entitled "Prickly Pear as Stock Feed." At its conclusion, Professor T. H. Johnston moved a vote of thanks, which was seconded by Mr. H. Tryon and supported by Mr. Gurney and the President. Mr. Smith suitably responded.

ABSTRACT OF PROCEEDINGS, 27TH APRIL, 1921.

The Ordinary Monthly Meeting of the Royal Society was held in the Geology Lecture Theatre of the University at 8 p.m. on the 27th April, 1921.

The President, Mr. C. T. White, F.L.S., in the chair.

His Excellency Sir Matthew Nathan and Lieut.-Colonel Parsons (private secretary) were among the visitors.

The minutes of the last monthly meeting were taken as read.

Mr. J. L. Froggatt, B.Sc., was nominated for Ordinary Membership.

The President then introduced Professor S. B. J. Skertchly, a Past-President of the Society, who gave a lecture on "Glacial Man." In an entertaining manner he outlined the events leading up to his discovery, in 1876, of palæolithic flint implements below the boulder clay of East Anglia. Although his conclusions were not generally accepted at the time, recent evidence supports them, and the lecture was the result of a special invitation to the Professor to speak on the subject. The actual implements, now in the Queensland Museum, were exhibited.

A hearty vote of thanks to Professor Skertchly was proposed by His Excellency the Governor, seconded by Professor H. C. Richards, supported by Mr. H. A. Longman and Dr. Shirley, and carried with applause from the large audience.

ABSTRACT OF PROCEEDINGS, 30TH MAY, 1921.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 30th May, 1921.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the last monthly meeting were read and confirmed.

The President extended a welcome to Professor Ernest H. Wilson, Assistant Director, Arnold Arboretum, Harvard University, who was present.

Mr. J. L. Froggatt, B.Sc., was elected to ordinary membership.

Captain S. A. White, C.M.B.O.U., delivered an interesting lecture entitled "The Aborigines of Central Australia," illustrated by a series of unique lantern slides.

A vote of thanks to Captain White was moved by Dr. J. Shirley, seconded by Professor Richards, supported by Professor Johnston, and carried by acclamation. The lecturer suitably responded.

Professor E. H. Wilson outlined some of the objects of the Arnold Arboretum, and give his impressions of the Australian true flora.

ABSTRACT OF PROCEEDINGS, 27TH JUNE, 1921.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University on 27th June, 1921, at 8 p.m.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. C. L. Thompson, B.D.Sc., was nominated for ordinary membership. Misses E. Muir and C. Moxon and Mr. F. W. Whitehouse were nominated as Associates.

Mr. H. A. Longman, F.L.S., exhibited a specimen of *Trachysaurus rugosus* Gray, the "Shingle-back Lizard," which had been born in the Museum on 11th May. When born this lizard was nearly half the size of its mother. This specific peculiarity was first pointed out in 1885 by Frederick McCoy.

A paper by C. D. Gillies, M.Sc., and P. W. Hopkins, M.C., entitled "The Phylogenetic Significance of the Prepollex and Prehallux: a Theory," was communicated by Mr. H. A. Longman, F.L.S. Dr. A. J. Turner, Messrs. Tryon and Longman, took part in the discussion.

Dr. J. Shirley, F.M.S., read a paper entitled "The Acacias of South-East Queensland," and illustrated his remarks by a series of lantern slides of photo-micrographs. The President commented on the paper.

Mr. O. W. Tiegs, M.Sc., submitted a paper by Professor T. H. Johnston, M.A., D.Sc., and himself entitled "New and Little-known Sarcophagïd Flies from South-Eastern Queensland," which was taken as read. Messrs. Tryon, Cooling, and Dr. Turner took part in the discussion.

Abstract of Proceedings, 25th July, 1921.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University on 25th July, 1921, at 8 p.m.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. C. L. Thompson, B.D.Sc., was elected an Ordinary Member. Misses E. Muir and C. Moxon and Mr. F. W. Whitehouse were elected as Associates.

Dr. J. Shirley, F.M.S., exhibited species of *Typhobia, Reymondia, Lithoglyphus, Syrnolopsis*, &c., from Lake Tanganyika. It was pointed out that these shells, with a marine facies, were absent from Lakes Victoria and Albert Nyanza and Nyassa, though similar species inhabit Lake Mweru to the west. The likelihood of geological formations containing these shells being regarded as of marine origin was also stressed.

Mr. H. A. Longman, F.L.S., exhibited the malformed hoof of a horse from Beerburrum, which had been donated to the Queensland Museum by Mr. T. B. Tripcony. The proximal, medium, and distal phalangeal bones were in pairs, whilst the hoof itself was tripartite, the median segment being very small. The specimen is of considerable interest as probably illustrating a reversion to an ancestral condition.

Mr. C. T. White, F.L.S., exhibited specimens of—(1) *Bassia lanuginosa* C.T.W., from sandstone country near the junction of the Mayne and Diamantina Rivers. The species, which is closely allied to the West Australian *B. carnosa* F.v.M., is characterised by exceptionally long silky hairs covering the perianth. (2) *Heliotropium indicum* Linn. This plant was recorded by F. v. Mueller in the Second

Systematic Census of Australian Plants as a native of the Northern Territory and Queensland. In Queensland, however, it has all the appearances of a naturalised weed and is spreading rapidly about many of the Northern townships.

Mr. H. A. Longman, F.L.S., read a paper entitled "The Magnificent Spider: *Dicrostichus magnificus* Rainbow: Notes on Cocoon spinning and method of catching prey." Mr. H. Tryon discussed the paper.

Mr. O. W. Tiegs, M.Sc., read a paper by Professor T. Harvey Johnston, M.A., D.Sc., and himself, entitled "On the Biology and Significance of the Chalcid Parasites of Australian Sheep Maggot-flies." Professor Johnston and Mr. Tryon took part in the subsequent discussion.

ABSTRACT OF PROCEEDINGS, 29TH AUGUST, 1921.

A Special Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on the 29th August, 1921.

His Excellency Sir Matthew Nathan, accompanied by Captain Harbord, A.D.C., was among the visitors.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

It was proposed by Professor Richards, seconded by Mr. F. Bennett, and carried by acclamation, that the congratulations of the Society be extended to Professor T. H. Johnston on his appointment to the chair of Zoology in the Adelaide University. At the same time much regret was expressed at Professor Johnston's eventual departure from Brisbane.

It was proposed by Professor Richards, seconded by Dr. Shirley, and carried unanimously, that Rule 29, so far as it refers to the number of printed papers (reprints) supplied to authors, be amended as follows:—

. . . Authors shall receive 25 copies of their printed papers *except in the case of joint authors when a maximum of 50 copies will be provided if requested.*

Dr. Douglas H. Campbell, Professor of Botany, Leland Stanford University, California, delivered a lecture entitled "Plant Distribution in the United States."

A vote of thanks to the lecturer was proposed by His Excellency Sir Matthew Nathan, seconded by Dr. Shirley, and carried with acclamation. Professor Campbell suitably responded.

ABSTRACT OF PROCEEDINGS, 26TH SEPTEMBER, 1921.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 26th September, 1921.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Miss B. Ludgate, B.A., and Mr. W. B. Alexander, M.A., were nominated for ordinary membership.

Dr. E. O. Marks exhibited a stone tomahawk found in alluvium at Bulimba Point, Brisbane, at a depth of 3 ft. 6 in. below the surface. Messrs. Bryan, Bennett, and Longman discussed the exhibit.

Mr. H. A. Longman, F.L.S., exhibited mandibles of *Phascolonus gigas* and *Euryzygoma* (*Nototherium*) *dunense.* In view of the discussion of species of *Nototherium* by Scott and Lord (Pr. Roy. Soc. Tas., 1921, p. 2) and their earlier association of De Vis' *dunense* with *Phascolonus,* as criticised by the exhibitor (Longman, Mem. Qld. Mus., VII, pt. 2, 1921, p. 77), these fossil marsupial mandibles were shown side by side. Not only are the dental characters totally distinct, but the large ectocrotaphyte depression and the associated external ridge readily distinguish all *Phascolomyidæ* from *Euryzygoma dunense,* which is the most specialised member of the Nototheriidæ yet found. The fact that the two families probably had a common ancestry does not make less remarkable their present divergencies. The exhibit was discussed by Mr. Bryan and Dr. Marks.

Mr. H. A. Longman communicated a paper by Mr.

L. E. Cooling entitled, "On the Larval and Pupal Stages of *Myzorhynchus bancrofti.*" The paper was discussed by Mr. Bennett and Mr. Tiegs.

Mr. W. D. Francis read a paper by Mr. C. T. White and himself entitled, "Contributions to the Flora of Queensland." The paper was discussed by Mr. Longman.

ABSTRACT OF PROCEEDINGS, 31ST OCTOBER, 1921.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 31st October, 1921.

Dr. J. Shirley, F.M.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. J. H. Reid was nominated for ordinary membership.

Miss B. Ludgate, B.A., and Mr. W. B. Alexander, M.A., were elected as ordinary members.

Dr. Shirley exhibited (1) a specimen of *Hakea plurinervia* F.v.M., given in the "Flora Australiensis" as from Rockingham Bay but found by Messrs. Tryon, White, and Shirley near Mount Gravatt; (2) specimens of the following shells from the Solomon Islands: *Chloritis eustoma* Pfr., *Microcystis nitidissima* E. A. Smith, *Papuina leucothœ* Pfr. and *P. vexillaris* Pfr., *Placostylus Strangei* Pfr., *Trochomorpha xiphias* Pfr.

Mr. H. A. Longman, F.L.S., exhibited a fossil fragment of a mandible of *Sarcophilus laniarius*, a carnivorous marsupial related to the Tasmanian "Devil" of the present day. The fragment consisted of part of the right side of the mandible with one molar well preserved. The fossil was found in the Guano Fertiliser Company's deposits, near Rockhampton, being donated to the Queensland Museum by Mr. P. H. Ebbott. Several remains of this animal have been secured from the Darling Downs.

Dr. H. I. Jensen delivered a lecture entitled "The Relation of the Oil Fields of the World to the Continental Shelves of the Archæan Continents." The Chairman, Dr. E. O. Marks, Mr. F. Bennett, and Hon. Randolph Bedford took part in the discussion.

ABSTRACT OF PROCEEDINGS, 28TH NOVEMBER, 1921.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 28th November, 1921.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Dr. A. J. Sawyer was nominated for Ordinary Membership.

Mr. J. H. Reid was elected as an ordinary member.

Dr. J. Shirley, F.M.S., exhibited specimens of Arcidæ from the following localities:—*Arca mosambicana* Bianconi, Solomon Islands; *A. nigra* Lamy, Moreton Bay, usually reported as *A. tenebrica*; *A. scapha,* Moreton Bay; *A. vellicata* Reeve, Elliot River. All these shells formed part of the collection of the late Dr. May, of Bundaberg, and were determined by Mons. Lamy of the Museum of Natural History, Paris.

Mr. H. A. Longman, F.L.S., exhibited the type specimen of *Nyctimene tryoni,* a new species of Megachiroptera, secured by Mr. D. Lahey at Canungra, South Queensland, and described in the Memoirs of the Queensland Museum, vol. vii, part 3. The occurrence of this tubular-nosed bat so far south of previous records for the genus was of special interest.

Mr. C. T. White, F.L.S., exhibited specimens of *Hedypnois polymorpha* Linn., a Mediterranean plant found as a naturalised alien near Brisbane by Mr. F. F. Coleman; *Cichorium intybus* Linn., the Chicory, and *Carthamus lanatus* Linn., the Saffron Thistle, both naturalised in Queensland for some years past but only now showing a tendency to become bad weeds; and *Lamium amplexicaule* Linn., Henbit or Dead Nettle, with which feeding experiments have recently been conducted in New South Wales showing the plant to be capable of causing the disease popularly known in Australia as "Staggers" or "Shivers." As yet the last-mentioned example is not a very common weed in Queensland.

Professor T. Harvey Johnston, M.A., D.Sc., read a paper by himself and Miss M. J. Bancroft, B.Sc., entitled "The Freshwater Fish Epidemics in Queensland Rivers." Dr. Shirley, Hon. A. J. Thynne, and Messrs. Longman, Sylow, and Alexander discussed the paper.

Publications have been received in exchange from the following Institutions and Societies, and are hereby acknowledged.

AFRICA.

Durban Museum, Durban.
Government of the Gold Coast.

AMERICA.

BRAZIL—

Instituto Oswaldo Cruz, Rio Janeiro.
Museu Paulista Suo Paulo.
Minesterio da Agricultura Industria and Commercio, Rio Janeiro.
Servio Geologio e Mineralogico de Brazil, Rio Janeiro.

CANADA—

Department of Mines, Ottawa.
Department of Agriculture, Ottawa.
Royal Astronomical Society of Canada, Toronto.
Royal Canadian Institute, Toronto.
Royal Society of Canada, Ottawa.

UNITED STATES—

American Academy of Arts and Sciences, Boston.
American Geographical Society, New York.
American Museum of Natural History, New York City.
Boston Natural History Society, Boston.
Californian Academy of Science, San Francisco.
Department of Commerce and Labour, New York.
Field Museum of Natural History, Chicago.
Geological and Natural History Society of Minnesota, Minneapolis.
Librarian Ohio State University, Columbus.
Missouri Botanic Gardens, St. Louis, Missouri.
National Academy of Science and Smithsonian Institute, Washington.
New York Academy of Sciences, New York.
University of California, Berkeley.
University of Minnesota, Minneapolis, Minnesota.
University of Illinois, Urbana.
University of Kansas, Lawrence.

OCEANIA—

Bernice Pauahi Bishop Museum, Honolulu, Hawaii Islands.

MEXICO—

Instituto Geologico de Mexico, Mexico.
Sociedad Cientifica.

ASIA.

INDIA—

Director Agricultural Institute, Pusa, Bengal.
Board of Scientific Advice for India, Calcutta.
Director Geological Survey of India, Calcutta.

JAVA—

Department van Landbrouw.
Koninklyke Naturkundige.

PHILIPPINE ISLANDS—

Librarian Bureau of Science, Manilla.

AUSTRALASIA AND NEW ZEALAND.

NEW ZEALAND—

Auckland Institute, Auckland.
Dominion Laboratory, Wellington.
Geological Survey of New Zealand, Wellington.
New Zealand Institute, Wellington.
New Zealand Board of Science and Art.

QUEENSLAND—

Department of Mines, Brisbane.
Field Naturalists' Club, Brisbane.
Geological Survey of Queensland.
Government Statistician, Brisbane.
Queensland Museum, Brisbane.

NEW SOUTH WALES—

Australian Museum, Sydney.
Director of Botanic Gardens, Sydney.
Department of Agriculture, Sydney.
Geological Survey of New South Wales, Sydney.
Linnean Society of New South Wales, Sydney.
Naturalists' Society of New South Wales, Sydney
Royal Society of New South Wales, Sydney.
University of Sydney.

SOUTH AUSTRALIA—

Geological Survey of South Australia, Adelaide.
Public Library of South Australia, Adelaide.
Royal Society of South Australia, Adelaide.

TASMANIA—

Geological Survey of Tasmania, Hobart.
Field Naturalists' Club, Hobart.
Royal Society of Tasmania.

VICTORIA—

Advisory Council Science and Industry, Melbourne.
Australasian Institute of Mining Engineers, Swanston Street, Melbourne
Commonwealth Statistician, Melbourne.
Field Naturalists' Club, Melbourne.

Department of Fisheries, Commonwealth, Melbourne.
Field Naturalists' Club of Victoria, Melbourne.
Royal Society of Victoria, Melbourne.
Scientific Australian, Melbourne.

WESTERN AUSTRALIA—

Geological Survey of West Australia, Perth.
Royal Society of West Australia, Perth.

EUROPE.

BELGIUM—

Société Royale, de Botanique de Belgique.
Academie Royale, Brussels.
Jardin Botanique, Brussels.
Institut de Sociologie Solvay, Belgium.

ENGLAND—

Cambridge Philosophical Society, Cambridge.
Conchological Society, Blackpool.
Literary and Philosophical Society, Manchester.
Royal Botanic Gardens, Kew, London.
Royal Colonial Institute, London.
Royal Society of London.
British Museum, London.
Imperial Bureau of Entomology, London.

FRANCE—

Institut de Zoologie de l'Université de Monpellier.
Société Botanique, Paris.

ITALY—

Laboratoria Zoolgia Generale di Agraria.
Società Africana d'Italia, Naples.

PORTUGAL—

Academia Polytechnica, Porto.

ROUMANIA—

Institute Meteorologie Central.

SCOTLAND—

Royal Society of Edinburgh.

SPAIN—

Academia Real de Ciencias, Madrid.
Academia Real dell Ciencias y Artes, Barcelona.
Junta Para Ampliacion de Estudios, Madrid.

SWITZERLAND—

Naturforschende Gesellschaft, Zürich
Société de Physique et d'Histoire, Geneva.

List of Members.

CORRESPONDING MEMBERS.

‡Danes, Dr. J. V.	Consulate-General for Czecho-Slovakia, Sydney.
David, Professor Sir T. W. E., F.R.S.	The University, Sydney, N.S.W.
‡Domin, Dr. K.	Czech University, Prague, Bohemia.
‡Hedley, C., F.L.S.	Assistant Curator, Australian Museum, Sydney, N.S.W.
Liversidge, Prof. A., F.R.S. ..	Fieldhead, Coombe Warren, Kingston Hill, Surrey, England.
‡Maiden, J. H., I.S.O., F.R.S., F.L.S.	Botanic Gardens, Sydney, N.S.W.
‡Maitland, A. Gibb., F.G.S. ..	Geological Survey Office, Perth, W.A.
Pollock, Prof. J. A., F.R.S. ..	The University, Sydney, N.S.W.
Rennie, Professor E. H. ..	The University, Adelaide, S.A.
‡Skeats, Professor E. W. ..	The University, Melbourne, Vic.

ORDINARY MEMBERS, ETC.

Alexander, W. B., M.A. ..	Prickly-pear Laboratory, Sherwood.
Appleby, W. E...	Sugar Refinery, New Farm.
Archer, R. S.	Gracemere, Rockhampton.
Bage, Miss F., M.Sc.	The Women's College, Kangaroo Point, Brisbane.
†Bagster, L. S., D.Sc.	The University, Brisbane.
‡†Bailey, J. F.	Botanic Gardens, Adelaide, S.A.
Ball, L. C., B.E.	Geological Survey Office, George Street, Brisbane.
‡†Bancroft, T. L., M.B.	Eidsvold, Queensland.
‡Bancroft, Miss M. J., B.Sc. ..	Medical School, The University, Sydney.
Barton, E. C., A.M.I.C.E. ..	Boundary Street, Valley, Brisbane.
Berney, F. L.	Barcarolle, *via* Longreach.
‡Bennett, F., B.Sc.	State School, Toowong, Brisbane.
Bick, E. W.	Botanic Gardens, Brisbane.
Bradley, H. Burton, M.B., Ch.M.	Longueville, North Shore, Sydney.
‡Brunnich, J. C., F.I.C... ..	Agricultural Chemist's Lab., William Street, Brisbane.
‡Bryan, W. H., M.Sc.	The University, Brisbane.
Brydon, Mrs.	Department Public Instruction, Brisbane.
Bundock, C. W., B.A.	"Kooralbyn," Beaudesert.
Butler-Wood, F., D.D.S. ..	Central Chambers, Queen Street, Brisbane.
Butler-Wood, Miss I. V., B.D.S.	Dornoch Terrace, West End.
†‡Byram, W. J.	Adelaide Chambers, Adelaide Street, Brisbane.

† Life Members.

‡ Members who have contributed papers to the Society.

Cameron, W. E., B.A. ..	Tanbun Road, Ipoh, Perak, Federated Malay States.
Cayzer, A. A., B.Sc.	The University. Brisbane.
‡Colledge, W. R..	Friendly Societies' Dispensary, George Street, Brisbane.
Colvin, Joseph	George Street, Brisbane.
Cooling, L. E.	Moreton Street, New Farm, Brisbane.
Cullen, J. R.	Puriri Street, Eastbourne, Wellington, N.Z.
‡Dodd, Alan P.	Sugar Experiment Station, Gordon Vale, *via* Cairns.
Drewitt, G. E.	Narandera, N.S.W.
Dunstan, B.	Geological Survey Office, George Street, Brisbane.
‡Francis, W. D.	Botanic Gardens, Brisbane.
Froggatt, J. L., B.Sc.	Department of Agriculture, Brisbane.
†Gailey, R.	Courier Buildings, Queen Street, Brisbane.
‡Gillies, C. D., M.Sc.	61 Wellington Street, Windsor, Melbourne.
Graff, R., B.Sc.	Grammar School, Ipswich.
‡Gray, Mrs. B. B.	care of Queensland Trustees Ltd., Margaret Street, Toowoomba.
Greene, Miss A.	High School, Wynnum.
Greenfield, A. P.	George Street, Brisbane.
‡Gurney, E. H.	Agricultural Chemist's Lab., William Street, Brisbane.
‡Hamlyn-Harris, R., D.Sc. ..	"Updown," Stanthorpe, Queensland.
Hardcastle, Mrs. T., B.Sc. ..	Jinbiggaree, near Dugandan.
‡Hawken, Professor R. W., B.A.	The University, Brisbane.
‡Henderson, J. B., F.I.C. ..	Government Analyst, Brisbane.
Hulsen, R.	238 Edward Street, Brisbane.
Illidge, T.	Markwell Street, Toowong.
Jackson, A. G.	Synchronome Co., Ann Street, Brisbane
Jensen, Dr. H. I.	Geological Survey Office, George Street, Brisbane.
†Johnston, J.	Department of Public Instruction, George Street, Brisbane.
‡Johnston, Professor T. Harvey, M.A., D.Sc.	The University, Brisbane.
‡Lambert, C. A.	care Bank of N.S.W., Melbourne, Vic.
Lloyd, W.	Queensland Correspondence College, Adelaide Street, Brisbane.
‡Longman, H. A., F.L.S. ..	Queensland Museum, Brisbane.
‡Love, W., M.B., Ch.M. ..	1 Wickham Terrace, Brisbane.
Ludgate, Miss B., B.A. ..	Menzies, George Street, Brisbane.
Marks, Hon. Dr., M.L.C. ..	101 Wickham Terrace, Brisbane.
Marks, Dr. E. O.	101 Wickham Terrace, Brisbane.
‡McCall, T., F.I.C.	Government Analyst's Department, Brisbane.

† Life Members.

‡ Members who have contributed papers to the Society.

Morris, L. C., A.M.I.C.E. ..	Department of Public Instruction, George Street, Brisbane.
Morton, C., A.T.C.S.M. ..	Geological Survey Office, George Street, Brisbane.
Moxon, Miss C.	Geology Department, The University (Associate).
Muir, Miss E.	Geology Department, The University (Associate).
Parker, W. R., L.D.S. ..	185 Edward Street, Brisbane.
‡Pearce, Mrs.	Elcho, 41 Belmont Road, Mossman, Sydney.
‡Pound, C. J., F.R.M.S. ..	Bacteriological Institute, Yeerongpilly.
Priestley, Professor H. J., M.A.	The University, Brisbane.
Reid, J. H.	Geological Survey Office, George Street, Brisbane.
‡Richards, Professor H. C., D.Sc.	The University, Brisbane.
†Riddell, R. M.	Department Public Instruction, Brisbane.
†Roe, R. H., M.A.	Figtree Pocket.
Saint-Smith, E. C., A.S.T.C. ..	Geological Survey Office, George Street, Brisbane.
Sankey, Major J. R.	Flavelle's, Queen Street, Brisbane.
Saunders, G. J., B.E.	Central Technical College, Brisbane.
‡Shirley, J., D.Sc.	Abbotsford Road, Bowen Hills, Brisbane.
‡Smith, F., B.Sc., F.I.C. ..	Hutton's Factory, Zillmere.
Soul, A. Valentine	Commercial Travellers' Club, Melbourne.
†Steel, T.	"Rock Bank," Stephens Street, Pennant Hills, Sydney, N.S.W.
†Stevens, Hon. E. J., M.L.C. ..	Southport.
Sutton, Dr. A., C.B., C.M.G. ..	Paddington.
Swanwick, K.ff., B.A., L.L.B...	The University, Brisbane.
Swain, E. H. F.	Director of Forests, Brisbane.
Sylow, Paul	Sugar Refinery, New Farm.
‡Taylor, Hon. W. F., M.L.C. ..	Preston House, Queen Street, Brisbane.
Thompson, C. L., B.D.Sc. ..	89-91 Queen Street, Brisbane.
Thynne, Hon. A. J., M.L.C. ..	195 Edward Street, Brisbane.
‡Tiegs, O. W., B.Sc.	The University, Brisbane.
‡Tryon, H.	Department of Agriculture, Brisbane.
‡Turner, Dr. A. J., M.D., F.E.S.	131 Wickham Terrace, Brisbane.
Walker, A. R., D.D.S., L.D.S.	Edward Street, City.
Walker, Miss Mavis J., M.Sc.	The University, Brisbane.
†Walkom, A. B., D.Sc.	Linnean Society House, Elizabeth Bay, Sydney.
Watkins, S. B., M.Sc.	Central Technical College, Brisbane.
Wearne, R. A., B.A.	Central Technical College, Brisbane.
†Weedon, W.	"Innisfail," Wickham Terrace, Brisbane.
‡White, C. T., F.L.S.	Government Botanist, Botanic Gardens, Brisbane.
Whitehouse, F. W.	Geology Department, The University (Associate).

† Life Members.

‡ Members who have contributed papers to the Society.

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PROCEEDINGS

OF THE

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OF

QUEENSLAND

FOR 1922.

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VOLUME XXXIV.

Presidential Address.

By C. T. White, F.L.S. (Government Botanist of Queensland.)

(Delivered before the Royal Society of Queensland, 11th April, 1922.)

I have taken as the scientific portion of my address a "Contribution to our Knowledge of the Flora of Papua (British New Guinea)," based on collections made there by me in 1918, but before proceeding with this subject would like to touch on a few matters of the past year of general interest to scientific workers in Queensland.

The Council's report for the past session shows that satisfactory progress has been made. It was regrettable that towards the end of the year the Council was obliged, owing to lack of funds, to discontinue the publication of papers submitted. By a special effort, however, the honorary treasurer (the late Dr. Shirley) was able before the end of the year to place our finances on a more satisfactory basis.

A sad feature has been the loss by death of four members of the Society.

William J. Byram, who died on the 10th March, 1922, was a native of Brisbane. He was educated at the Brisbane Grammar School, where in 1880 he won the Lilley Gold Medal as head of the school. He was well known in legal and business circles in Brisbane. He was a good classical scholar, and within the last few years of his life had produced a verse translation of Æschylus' "Prometheus Vinctus" so scholarly and so poetic, especially in the rendering of its choruses, that Prof. Gilbert Murray (Oxford Professor of Greek), to whom it was submitted, said he was proud to think it was the work of a fellow-countryman (he himself being an Australian). The translation is now in the Queensland University Library, where it may serve as an incentive to future classical scholars. The late Mr. Byram was a keen microscopist, being especially interested in Freshwater Algæ, and helped the late F. M. Bailey in bringing out the three bulletins of the Botany Series published by the Queensland Department of Agriculture and Stock devoted to the Freshwater Algæ of Queensland, by translating from the German the original descriptions forwarded to Mr. Bailey from European specialists who had submitted to them the material upon which the bulletins referred to were based. An appreciation of the late Mr. Byram from the pen of Mr. R. H. Roe, one-time head master of the Brisbane Grammar School and later Director of Education in Queensland, appeared in

the *Brisbane Courier* for the 18th March, 1922, and from this some of the above facts have been taken.

ROBERT LOGAN JACK, LL.D., F.R.G.S., F.G.S., who died in Sydney in November, 1921, was born at Irvine, Ayrshire, Scotland, on the 16th September, 1845, and was educated at the Irvine Academy and Edinburgh University. For some years he was attached to the Geological Survey of Scotland and also conducted geological work on the Continent. In 1877 he was appointed Government Geologist for Northern Queensland in succession to Richard Daintree, and was soon afterwards appointed Chief Government Geologist for Queensland. While holding office he conducted much exploratory work, and published a number of original contributions to our knowledge of the geology of the State. In 1893, in collaboration with R. Etheridge, junr., he brought out the well-known "Geology and Palæontology of Queensland and New Guinea." In 1898 he was appointed Commissioner for Queensland to the Earl's Court Exhibition, London, and while there received an offer from an English company operating in the East which caused him to resign his position as Government Geologist of Queensland. Operations in the East ceasing owing to the Boxer outbreak, he returned to England, where he started private practice as a consulting geologist and mineralogist. He returned to Australia in 1904, and was for some years engaged in private practice in West Australia, afterwards coming to Sydney. For some years before his death he was engaged on a study of the history of exploration in Northern Australia, and the two-volume work "Northernmost Australia" is the result.

JOHN SHIRLEY, D.Sc., F.M.S., a past-president, hon. secretary, and for some years before his death the very efficient hon. treasurer of this Society, who died in Brisbane on the 5th March, 1922, was born at Dorchester, England, on the 11th August, 1849. With the passing of Dr. Shirley Queensland has lost one of its most brilliant educationalists and the Royal Society and also the Australasian Association one of their most zealous officers. Dr. Shirley began official life as a pupil teacher, being trained in the Curzon-street National School, Derby, England, and subsequently entered as a student of the Saltley Training College, where he remained till 1869.

After completing his course in the training college he was employed for a period of eight years in Bishop Ryder's Boys' School, Birmingham, and whilst at that school graduated as B.Sc. of the London University. He arrived in Queensland in

May 1878, and on 1st June of that year was appointed head teacher of the State School at Roma. In 1879 he was appointed District Inspector of Schools and in 1909 Senior Inspector. When the Teachers' Training College was established in 1914 he was selected for the position of principal. He held this post till the end of 1919, when he was retired under the provisions of the Public Service Act. The following year, however, he was appointed conchologist to the Queensland Museum, a post he had in previous years filled in an honorary capacity. This position he held for one year and nine months, when the pruning knife of retrenchment did away with the position. It was characteristic of him that when over sixty years of age he employed the long leave due to him for continuous Government service in studying, and preparing a thesis for the degree of Doctor of Science at the Sydney University. He was a versatile writer on scientific subjects, being one of the older school of naturalists whose studies covered a number of branches of natural science. His most important published work was the "Lichen Flora of Queensland" (mostly first published as a series of papers in the Proceedings of this Society).

The Hon. ERNEST JAMES STEVENS, M.L.C., who died at Brisbane on the 3rd March, 1922, was born at Melbourne on the 10th July, 1845. He came to Queensland in 1868 and for some years engaged in pastoral pursuits. He was elected M.L.A. for Warrego in 1878 and for the Logan in 1883. He retired in 1899 and was called to the Legislative Council. He was one of the more prominent business men of Queensland, for some years among other posts being chairman of directors of the Brisbane Newspaper Company Limited.

In April the Council was aked to nominate candidates for election to the newly formed Australian National Research Council. It is hoped the formation of the Council will materially aid scientific advancement in the Commonwealth.

The early part of 1921 was marked by the holding of the Hobart-Melbourne meeting of the Australasian Association for the Advancement of Science. The meeting was the first held since 1913, and such a long time elapsing between meetings gave many of us the opportunity of again meeting old friends from other States, and kindred spirits whom previously we only knew by reputation or through correspondence. It is much to be regretted that funds did not permit the many papers read being printed as a record. Many, however, have since appeared in various scientific periodicals.

An event of interest among local natural history circles was the amalgamation of the Queensland Field Naturalists' Club with the Gould League of Bird-lovers, under the title of the "Queensland Naturalists' Club," the Gould League being embodied in a junior section known as the "Nature-lovers' League." In the past both bodies have done excellent work in their respective spheres, and it is hoped the amalgamation will mean an increased activity in natural history matters in Queensland, particularly in fostering a love among the rising generation for our beautiful native birds, animals, and plants.

The inauguration of a Queensland branch of the British Empire Forestry Association at a public meeting held during the Interstate Forestry Conference recently held in Brisbane, is a matter for congratulation, and it is hoped the newly formed association will be able to foster a keen public spirit towards forestry matters in Queensland, particularly as regards the conservation and regeneration of our more important timber trees. Our total tree flora is not yet known and every year sees new species brought to light, and I would here make a plea for a proper botanical survey of our more richly timbered areas, particularly those at present little known.

In his "Discussion of Australian Forestry" the late Sir D. E. Hutchins states: "Those who do not know Australia will hardly credit the assertion that after a white occupation of one hundred years or more the country is still without a single national arboretum." He goes on to describe the large arboretum at Tokai, near Capetown, South Africa, in which about 150 species of eucalypts are growing. He then goes on to make a plea for the establishment of suburban forests or arboreta near the larger towns. "The Centennial Park," he says, "is a splendid open space in nearly the centre of Sydney for a suburban forest. Certainly if one-third of the space was kept open for lawns, flower-beds, and ornamental water, the remaining two-thirds might be devoted to an arboretum, which would be the centre of arboriculture in New South Wales and from many points of view would be the leading feature of the city of Sydney." In Brisbane we have a similar large open space in Victoria Park, at present a more or less neglected area, which would make an ideal site for a large collection of trees within the city boundaries. It has one feature in common with the Centennial Park—i.e., a very poor, barren soil—but a lot of this land could be reclaimed with city refuse at a reasonable cost.

A Contribution to our Knowledge of the Flora of Papua (British New Guinea).

By C. T. White, F.L.S. (Government Botanist of Queensland.)

(*Scientific Portion of Presidential Address delivered before the Royal Society of Queensland, 11th April, 1922.*)

INTRODUCTORY.

In June 1918 I received an invitation from His Excellency Judge Murray, Lieutenant-Governor of Papua, to visit the Territory for the purpose of studying its vegetation, of which comparatively little is known. The invitation came at a time when six weeks' leave of absence was due to me from the Queensland Department of Agriculture and Stock. Pressure of other matters prevented me from spending much more than my official leave on the visit, and only between five and six weeks' actual collecting was spent in the field. About 800 species of vascular plants were gathered ; the majority of the material has now been worked out and the results are here set forth.

The references to literature are confined to such as refer to the occurrence of the particular species in the territory of Papua (British New Guinea). Some of the families have been sent to various specialists for examination, and to these botanists I must express my special thanks. To Dr. Rendle, Keeper of Botany, British Museum of Natural History, I am indebted for arranging for Mr. Spencer Le M. Moore, B.Sc., F.L.S., to work out the Acanthaceæ and Rubiaceæ ; also for handing over to Mr. H. N. Ridley, late Director of Botanic Gardens, Singapore, the specimens of Musaceæ, Zingiberaceæ, and Marantaceæ. To Mr. J. H. Maiden, Director of Botanic Gardens, Sydney, I am indebted for the identification of the eucalypts, and for arranging for the working out of the ferns by Mr. Whitelegge and the Loranthaceæ by Mr. Blakely.

I have taken the opportunity of recording a few plants for Papua from specimens in the Queensland Herbarium, that had been lying there undetermined for some years. There still remains more doubtful material in the Queensland Herbarium, and I hope to work these specimens out later along with my own undetermined material.

ITINERARY.

After a few days' stay in Port Moresby, I left in company with the Papuan Government Geologist (Mr. Evan R. Stanley) and fifteen carriers for the Sogeri Plateau and Javararie, *via* Sapphire Creek and the Astrolabe Range (about 2,000 feet). After about a fortnight spent in this territory, I returned to Port Moresby and after a few days' stay left for Yule Island and Mafulu, again having the advantage of the company of Mr. Stanley.

At Yule Island twenty-five native carriers were obtained for carrying the camping outfit, collecting gear, specimens, &c. The journey was made over to the mainland and up the Ethel River as far as Bioto by native canoes. Time did not permit of much collecting along the banks of the Ethel River, though the mangrove swamps, Nipa palms, and rich tropical vegetation fringing the banks of the river and of Bioto Creek promised a good field for the botanist.

On reaching Bioto, the canoes were drawn up on the bank and the five days' march to the mountains commenced, the following places being stopped at *en route*:—Kubunah, Fofofofo, Dilava, Deva Deva, Mafulu, and Bella Vista. An excellent well-graded road has been surveyed and made under the direction of the Mission Fathers, from Bioto as far inland as Onongc, which makes travelling in this country comparatively easy; and travellers in the Mekeo, Dilava, and Mafulu districts—the sphere of influence of the Roman Catholic missions—are indebted to the missionaries for the facilities with which travelling can be accomplished in these parts of Papua.

GENERAL NOTES ON THE VEGETATION.

The vegetation about Port Moresby reminds one of much of the open forest country in parts of North Queensland with a similar rainfall (about 40 in.). It consists for the most part of grass-covered hills with scattered white-barked eucalypts (*E. papuana* and *E. alba*) of rather stunted growth dotted about.

Other very common trees on the hills are *Alstonia scholaris* (Milky Pine), and *Albizzia procera*. A cycad (*Cycas media*) is also very abundant. In the gullies and round the sea-beach are found patches of thin scrub supporting a more varied flora. Every here and there bright masses of scarlet can be

seen—the flowers of *Bombax malabaricum* (the Silk Cotton tree)—a large tree ranging through North Australia, New Guinea, and Tropical Asia. Round about the rocky sea-coast, near the town, *Cochlospermum Gillivræi* (a small tree) is conspicuous on account of its numerous large, yellow, buttercup-like flowers. *Cordia subcordata* is another fairly common shrub in the same situation.

Swampy patches occur in which the Sago Palm (*Metroxylon* sp.) and Breadfruit (*Artocarpus incisa*) predominate. The mangrove flora along the southern coast is similar to that of the North Australian and Malayan regions, consisting of *Rhizophora*, *Bruguiera*, *Ceriops*, *Sonneratia*, *Avicennia*, *Ægiceras*, and *Carapa*. *Acanthus ilicifolius* is in some parts also abundant. A common climber over mangrove trees is *Dalbergia monosperma*. Along the Ethel River and Bioto Creek the Nipa Palm (*Nipa fruticans*) is a conspicuous feature lining both sides of the banks. Along the Ethel River I also collected specimens of the apparently little-known *Sonneratia lanceolata*. It is a small tree very much resembling some forms of *Avicennia officinalis* in appearance ; its pneumatophores also are like those of *Avicennia*, and do not attain the large size of its congener *S. alba*.

On the Astrolabe Range (about 3,000 feet), Hombrom Bluff, Mt. Warirata, etc., the vegetation for the most part is of an open character, the principal forest trees being eucalypts (principally *E. tereticornis*) with patches of *E. alba* and *E. clavigera*, *Casuarina nodiflora*, *Banksia dentata*, *Melaleuca* sp. (a Paper-barked Tea-tree), *Diplanthera tetraphylla*, *Grevillea pinnatifida*, and *Timonius Rumphii*. At Bisiatabu I was interested to find *Nepenthes Moorei* to be a common plant in the poorer open, dry, forest country. The lower trees in the same place supported a number of plants of *Myrmecodia* and *Dischidia*. On the Sogeri Plateau itself the vegetation is very rich and tropical, the plateau being mostly covered with heavy rain-forest in which the usual Malayan orders and genera predominate. Zingiberaceæ and Marantaceæ are particularly abundant. *Mucuna Krœtkei* is a forest climber with long pendulous racemes of brilliant scarlet flowers and is known locally as the "D'Albertis Creeper," a name applied in a general sense by the white people resident in Papua to any climber of the genus *Mucuna*.

Sogeri Plateau is a great centre of rubber cultivation, and

several large and successful plantations have been established there. Further on, Javararie—nearly 50 miles by road from Port Moresby—is one of the oldest rubber plantations and produces some of the finest rubber in the Territory ; but the lack of decent road communication with the seaport militates greatly against its financial success. Botanically, round Javararie the country is particularly rich and tropical in character, and a large number of plants was here gathered.

On Yule Island and on the mainland opposite the vegetation is somewhat similar to that about Port Moresby. In the ranges about Mafulu (about 4,000 feet) the vegetation is extremely rich and varied, consisting almost entirely of heavy rain-forest. Among trees the ordinary Malayan types predominate ; ferns, lycopods, begonias, palms, bamboos, and other typical tropical forms are abundant. The occurrence of *Grevillea* is a connecting link with the flora of Australia, while *Quercus*, *Castanopsis*, and *Begonia* are Asiatic types not as yet found in Australia.

A BRIEF HISTORY OF BOTANICAL WORK IN PAPUA.

There has been considerably less botanical work accomplished on the territory of Papua or British New Guinea than in either the Dutch or late German territories. In his introductory notes to the Botany of the Wollaston Expedition, Dutch New Guinea (in Trans. Linn. Soc., vol. ix, Bot. 2nd series), Mr. H. N. Ridley stated : " The flora of British New Guinea has been more neglected than that of Dutch and German New Guinea ; except for Forbes's collections on the Sogeri Mountains, which have not yet been fully worked out, and a small lot obtained by MacGregor and Guilianetti, no collecting of importance has been done there."

In 1875 Wm. Macleay (afterwards Sir. Wm. Macleay) conducted an expedition to the islands of Torres Strait and to New Guinea. J. Reedy accompanied the expedition as an horticultural emissary of Sir William Macarthur. The specimens he collected formed the material for the first part of Mueller's " Descriptive Notes on Papuan Plants."

In 1875 the Rev. Dr. McFarlane, in search of suitable places to establish mission stations, made the first voyage up the Baxter and Fly Rivers. He collected a number of plants, which were described by Baron Ferdinand von Mueller in his " Descriptive Notes on Papuan Plants," vol. i, pts. 2 and 3.

In 1876-7 Mr. Andrew Goldie, first in conjunction with the Rev. Dr. McFarlane and, in a later expedition, by himself, forwarded collections of plants to Baron Mueller, which were described by the Baron in his "Descriptive Notes," vol. i, Nos. 3, 4, and 5.

During 1875-7 the famous explorer Signor D'Albertis conducted explorations up the Fly River and made important collections. These were determined in part by Dr. O. Beccari in D'Albertis' "New Guinea," vol. ii, pp. 391-400, and in part by Baron Mueller in "Descriptive Notes" (vol. i, Nos. 4 and 5). Some of his plants are also described in Beccari's "Malesia."

In 1884 the *Argus* and the *Age* (Melbourne newspapers) sent special commissioners to Papua to report upon its resources and capabilities for settlement. The *Argus* Expedition was commanded by Mr. W. E. Armit, an officer of the Queensland Native Police; he was a true plant-lover, and his specimens were referred to by Mueller in odd numbers of the "Victorian Naturalist" for the year 1885.

During 1884-1887 Theodore Bevan conducted several expeditions to totally unexplored or little-known parts. His collection of plants was briefly noted by Mueller in "Proceedings of the Linnean Society of N.S.W.," vol. ii, n.s.

During the same period the Rev. Jas. Chalmers forwarded to Baron Mueller several small collections. These were noted by Mueller in his "Descriptive Notes" Nos. 6-8.

In 1885, H. O. Forbes, well known as an explorer through having conducted expeditions in Sumatra, Timor, and some of the lesser-known islands of the Malayan Archipelago, visited New Guinea for the purpose of exploring the Owen Stanley Range. Unfortunately, owing to lack of funds and other obstacles, Forbes was not able to realise his object, and a large camp was established at Sogeri, where most of the collecting was accomplished. The Monocotyledonous plants were described by H. N. Ridley (Journal of Botany, vol. xxiv), but the great bulk of Forbes's collections, sad to say, remain undetermined to this day, and odd references to new species collected by Forbes are now and again met with in current literature dealing with the flora of New Guinea. It is interesting to record here that this Society, through the efforts of its then hon. secretary (Mr. H. Tryon), was able to send to Forbes the sum of £100 in aid of his work.

In 1886 the Geographical Society of Australia despatched a well-equipped expedition under the leadership of Captain H. E. Everitt. Mr. W. Bauerlen accompanied the party as botanical collector, and his collections were determined and described by Baron Mueller in his "Descriptive Notes" (vol. ii, Nos. 7 and 8). Bauerlen also issued a booklet, "The Voyage of the Bonito" (Sydney 1886), giving an account of the voyage, but it contains little botanical matter.

In 1887 Messrs. Cuthbertson, Sayer, and Hunter ascended Mt. Obree. Sayer, well known as a botanical collector and one of the first white men to ascend Bellenden-Ker, North Queensland, collected a number of plants which were described by Mueller in the "Victorian Naturalist" and his "Descriptive Notes." Only a very few plants were noted, and I think a number more are probably lying undetermined in the National Herbarium, Melbourne.

In 1887 C. Hartmann, a well-known Queensland plant enthusiast, accompanied by G. Hunter, ascended the eastern bank of the Kemp-Welch River and pushed forward with the intention of going to the top of the range between Mt. Brown and Mt. Obree, an ideal not fully realised. They are reputed to have collected a large series of specimens. I can find very few references to Hartmann's specimens—only a few by Mueller ("Descriptive Notes") and Bailey ("Queensland Agricultural Journal"). Possibly the main bulk are still lying undetermined in the National Herbarium at Melbourne.

In 1889 Sir William MacGregor ascended the Owen Stanley Range to its highest point (Mt. Victoria, 13,121 feet), and collected an important series of specimens from the higher altitudes. These were described by Baron Mueller in "Transactions of the Royal Society of Victoria," vol. i, pp. 1-45. It constitutes one of the most important contributions to our knowledge of the flora of the territory. During his term of office as Lieutenant-Governor of Papua, Sir William MacGregor collected a number of specimens of plants. These were determined by Mueller and recorded in various papers, largely as appendices to the Annual Reports of British New Guinea.

In 1895-6 H. Tryon visited British New Guinea, as an emissary of the Queensland Department of Agriculture, for the purpose of procuring varieties of sugar-cane for cultivation in Queensland. Tryon spent about 4½ months in the territory and brought back to Queensland 65 varieties of sugar-cane

from native gardens. Some of these, e.g. Badila, are among the most generally cultivated in Queensland at the present time. A very comprehensive report by him on his collections was unfortunately never printed.

In 1897 (after Mueller's death) Sir William MacGregor forwarded to the Royal Botanic Gardens, Kew, a collection of plants from the higher parts of Mt. Scratchley. This was followed up by a collection from the Vanaipa Valley and Wharton Range, made by A. C. English. These two collections were described in the "Kew Bulletin" for 1899, pp. 95-126. Lists are also given in the Annual Report of British New Guinea for 1897-8.

In 1898 F. M. Bailey, Colonial Botanist of Queensland, accompanied His Excellency Lord Lamington (then Governor of Queensland) and Sir Hugh M. Nelson on a tour of inspection of British New Guinea. He gives a list of the plants observed in an appendix of a parliamentary paper, "Report of Visit to British New Guinea" (1898). The new species collected were described in the "Annual Report of British New Guinea" and "Queensland Agricultural Journal."

From 1899-1903, during his years of office as Lieutenant-Governor of the Territory, Sir G. R. Le Hunte forwarded a number of specimens to F. M. Bailey for determination. These were described in the pages of the "Queensland Agricultural Journal" and as appendices to the "Annual Reports of British New Guinea."

During 1904-7 Captain F. R. Barton, while holding the post of Administrator, forwarded several lots of specimens to F. M. Bailey for examination. These were described in the "Queensland Agricultural Journal" and one collection in the Proceedings of this Society (vol. xviii).

In 1908 Gilbert Burnett, a Queensland district forest inspector, visited Papua for the purpose of reporting on the timber resources of the territory. His report is embodied in the "Timber Trees of the Territory of Papua," a 45-page booklet issued by the Department of External Affairs, Melbourne. Of the numerous timbers listed, with two or three exceptions, only native Papuan names are given. A fine opportunity was here lost of doing good botanical work.

In 1908 Mrs. H. P. Schlencker, wife of one of the London Missionary Society's officers, made collections about Boku.

These were determined and described by F. M. Bailey and the results published in his "Contributions to the Flora of British New Guinea" series in several issues of the "Queensland Agricultural Journal," during 1909.

In 1911 E. B. Copeland described in the Philippine Journal of Science (vol. vi, section C, pp. 65-92) a number of ferns submitted to him by the Rev. Copland King. The Rev. King was a keen collector of Papuan ferns and orchids, and practically speaking confined his attention to these plants. His orchids and many of his ferns were described by F. M. Bailey in the pages of the "Queensland Agricultural Journal" in his series "Contributions to the Flora of British New Guinea."

PTERIDOPHYTA.

(Determined by Thos. Whitelegge, Consulting Pteridologist, Botanic Gardens, Sydney).

POLYPODIACEÆ.

Aspidium subtriphyllum Hook. Astrolabe Range.

A. cucullatum Christ. Mt. Warirata (Astrolabe Range).

Nephrolepis floccigerum Moore.

N. laurifolium Christ. Mekeo District.

N. biserrata Sw. Copel. Phil. Journ. Sc. Bot., vi, 81, 1911. Sogeri; Javararie; Mafulu.

N. dicksonioides Christ. Deva Deva and Mafulu.

Onychium tenue Christ. Copel. Phil. Journ. Sc. Bot., v 86, 1911. Laloki River.

Diplazium elongatum Sw. Sogeri.

D. tenerum Forst. Fofofofo.

Anisogonium cordifolium Bedd. (*Diplazium cordifolium* Bl.). Near Fofofofo.

Blechnum orientale L. Beccari in D'Albertis' "New Guinea," 2, 399; F. Muell. Pap. Pl., i (4), 81; Copel. Phil. Journ. Sc. Bot., vi, 84, 1911. Astrolabe Range.

Doryopteris concolor Kuhn. Sapphire Creek.

Cheilanthes tenuifolia Burm. F. Muell. Pap. Pl., 1 (3), 48; Bail. Queens. Agric. Journ., xxiii, 159, 1909; Copel. Phil. Journ. Sc. Bot., vi, 86, 1911.

Hypolepis papuana Bail., Queens. Agric. Journ., xxiii, 158, 1909. Astrolabe Range.

Adiantum lunulatum Burm. F. Muell. Pap. Pl., 1 (3), 49. Javararie.

Pteris longifolia Linn. F. Muell. Pap. Pl., i (1), 16 ; Copel. Phil. Journ. Sc. Bot., vi. 85, 1911. Port Moresby.

P. orientalis A. v. R. Mafulu.

P. semipinnata Linn. Beccari in D'Albertis' "New Guinea," 2, 399 ; F. Muell. Pap. Pl., i (4), 78. Dilava.

Histiopteris stipulacea (Hook.) Copel.

Pteridium aquilinum Kuhn., var. **lanuginosum** A. v. R. Astrolabe Range and Sogeri (very abundant).

Vittaria angustifolia Bl. Mafulu.

Tænitis blechnoides (Willd.) Sw. F. Muell. Pap. Pl., 2 (6), 22 ; Copel. Phil. Journ. Sc. Bot., vi, 86, 1911. Deva Deva.

Meniscium triphyllum Sw. Sogeri.

Dictyogramme pinnata J. Sm. (*Syngramma pinnata* J. Sm.). Copel. Phil. Journ. Sc. Bot., vi, 84, 1911. Mekeo District.

Drynaria sparsisora Moore. Copel. Phil. Journ. Sc. Bot., vi, 91, 1911. Laloki River and Sapphire Creek.

D. rigidula (Sw.) Bedd. Copel. Phil. Journ. Sc. Bot., vi, 91, 1911. (*Polypodium rigidulum* Sw., Bail. Queens. Agric. Journ., xxiii, 159, 1909.) Mafulu.

Dipteris conjugata Reinw. (*Polypodium Dipteris* Bl.). F. Muell. Vic. Naturalist, Feb. 1885, and Pap. Pl., 2 (6), 22. Mafulu.

Polypodium nigrescens Bl. Road between Sogeri and Javararie.

Acrostichum aureum L. F. Muell. Pap. Pl., i (4), 76 ; Copel. Phil. Journ. Sc. Bot., vi, 92, 1911. Yule Island.

A. aureum L., var. **attenuatum** A. v. R. Port Moresby.

GYMNOSPERMÆ.

Family CYCADACEÆ.

Cycas media R. Br. Port Moresby ; [Boku, *Mrs. H. P. Schlencker*]. This Cycad is very abundant on the hills about Port Moresby ; the leaflets are densely pubescent on the under surface and I have little hesitation in referring it to the very common Australian *C. media.*

C. circinalis Linn. (*C. papuana* F. Muell. Pap. Pl., i (iv), 71 ; Becc. in D'Albertis' "New Guinea," ii, 399 ; Bail. Rep.

Visit B.N.G., 27, and Queens. Agric. Journ., xxii, 149.) Mekeo District (also observed but not collected on the road between Sogeri and Javararie).

C. media is a denizen of the dry open forest or grass lands characteristic of a good stretch of the coastal country in Southern Papua, and I have a strong suspicion that the specimens referred to by Bailey l.c. belong to it rather than to *C. circinalis.* However, I cannot find any specimens in the Queensland Herbarium referred to *C. papuana* by him. *C. circinalis* is a very different looking plant and is an inhabitant of the dense rain-forests of the mountains. Schumann and Lauterbach (Fl. Deutsch. Schutz. Gebiete Sudsee, p. 153) place *C. Rumphii* Miquel as a synonym; and as Hooker (Flora British India, v, 657) places *C. Seratchleyanum* as only a form of this, that would leave only two species recorded for the territory of Papua.

Family PINACEÆ.

(Coniferæ.)

Araucaria Cunninghamii Ait. F. Muell. Vic. Nat. iv, 121; Pap. Pl., ii (ix), 65. Mafulu (not very abundant).

MONOCOTYLEDONÆ.

Family PANDANACEÆ.

(Determinations verified by Prof. U. Martelli (Firenze).)

Pandanus Balenii Martelli. Between Sogeri and Javararie.

Freycinetia angustissima Ridl. in Britt. Journ. Bot., xxiv, 359. Bisiatabu (Astrolabe Range).

Family GRAMINEÆ.

(Grasses.)

Coix Lacryma-Jobi Linn. F. v. M. Pap. Pl., i (ii), 31; Becc. in D'Albertis' "New Guinea," ii. 399; Bail. Rep. Visit B.N.G., 28; Queens. Agric. Journ., iii. 162, xxii, 150. Javararie (also noticed at Kabunah).

Polytoca macrophylla Benth. Mt. Warirata and Mafulu.

Dimeria ornithopoda Trin. Bisiatabu (Astrolabe Range). A small grass growing on rocks in exposed situations.

Imperata arundinacea Cyr. F. Muell. Pap. Pl., ii (vi), 20; Vic. Nat., Feb. 1885; Bail. Rep. Visit B.N.G., 28. Astrolabe Range. Common in open forest country almost everywhere; a great pest in coconut plantations.

Saccharum spontaneum Linn. F. Muell. Pap. Pl., i, (iii), 46. Yule Island. My specimens are in a very advanced condition and imperfect, but seem referable to the above.

Miscanthus floridulus Warb. Mafulu.

[**Pollinia grata** Hack. Waigani, *C. N. Loudon.* For the identification of this grass I am indebted to the Director, Royal Botanic Gardens, Kew, England.]

Ischæmum cordatum Hack. Bella Vista.

Apluda mutica Linn. F. Muell. Pap. Pl., i (iii), 46. Port Moresby, Yule Island.

Manisuris granularis Sw. On range between Sogeri and Javararie.

Elionurius citreus Munro. Astrolabe Range.

Ophiuris corymbosus Gærtn. Astrolabe Range.

Heteropogon contortus Rœm. et Schult. Bunch Spear Grass. Bail. Rep. Visit B.N.G., 27 ; (*Andropogon contortus* Linn.) ; F. Muell. Pap. Pl., i (iii), 46. Port Moresby.

Andropogon sericeus R. Br. Queensland Blue Grass. Port Moresby ; [B. N. Guinea, without precise locality, *G. R. Le Hunte.*]

A. annulatus Forst. Port Moresby.

A. nardus Linn., var. **grandis** Hack. Port Moresby. My specimens of these three species of *Andropogon* are imperfect, and it is desirable that further specimens should be obtained to verify the specific determinations.

Chrysopogon aciculatus Trin. Sogeri.

Sorghum fulvum Beauv. Port Moresby.

Anthistiria imberbis Retz. *A. ciliata* F. Muell. Pap. Pl., i (iii), 47 ; Bail. Rep. Visit to B.N.G., 27 (*non* Linn.). Port Moresby ; Yule Island.

Paspalum scrobiculatum Linn. F. Muell. Pap. Pl., ii (vii), 35 ; Bail. Rep. Visit B.N.G., 28. Mafulu.

P. longifolium Roxb. (*non* Steud.), now kept by many botanists as distinct from *P. scrobiculatum*, has been recorded by F. Muell. Pap. Pl., i (iv), 74, and by Beccari in D'Albertis' "New Guinea," ii, 399, as from Papua (British New Guinea).

P. distichum Linn., var. **littorale** (R. Br.) Bail. Yule Island.

P. conjugatum Berg. Astrolabe Range ; Sogeri ; Javararie. A common grass in rubber plantations, sides of roads, &c.

Eriochloa punctata Hamilt. F. Muell. Pap. Pl., i (iv), 74. Port Moresby.

Isachne myosotis Nees. On rocks, Rona Falls (Astrolabe Range); Mafulu.

Panicum sanguinale Linn. F. Muell. Pap. Pl., i (iii), 47: Bail. Queens. Agric. Journ., iii, 161; Rep. Visit B.N.G., 28. Sogeri.

P. crusgalli Linn. F. Muell. Pap. Pl., ii (vii), 35. Laloki River; Koitaki (Sogeri District).

P. patens Linn. Bail. Queens. Agric. Journ., xxiii, 219. Astrolabe Range; Sogeri; Mafulu.

P. sarmentosum Roxb. Bisiatabu; Sogeri. Very abundant along forest tracks.

P. indicum Linn. Bella Vista. Rather a slender form.

P. prostratum Lam. Yule Island.

P. plicatum Lam. F. Muell. Pap. Pl., ii (vi), 19; Vic. Nat., April 1885. Mafulu.

Arundinella nepalensis Trin. Port Moresby.

Thysanolæna maxima O. Kze. Fairly common on road from Fofofofo to Mafulu.

Setaria glauca Beauv. F. Muell. Pap. Pl., ii (vi), 19; Vic. Nat., Feb. 1885. Bella Vista.

Pennisetum macrostachyum Trin. F. Muell Pap. Pl., ii (vi), 19; Vic. Nat., Feb. 1885; Bail. Queens. Agric. Journ., xxiii, 220. Laloki River.

Cenchrus echinatus Linn. C. T. White, Queens. Agric. Journ., ix, n.s. 180, pl. 14. *Pennisetum cenchroides* Bail. Queens. Agric. Journ., xxiii, 220 (*non* Rich.). Port Moresby: very common.

Leptaspis urceolata R. Br. F. Muell. Pap. Pl., ii (viii), 57; Ridley in Journ. Bot., xxiv, 360. Astrolabe Range.

Eriachne Armitii F. Muell. Hombrom Bluff (Astrolabe Range).

Centotheca lappacea Desv. Bail. Queens. Agric. Journ., ix, 411. Astrolabe Range; Sogeri; Javararie. Very common.

Lophatherum gracile Brongn. Hemsley in Kew Bulletin, 1899, 115. Sogeri.

Chloris barbata Sw. Port Moresby.

Eleusine aristata Ehrenb. Port Moresby.

E. indica, Gærtn. F. Muell. Pap. Pl., ii (vi), 20; Bail. Rep. Visit B.N.G., 28. Laloki River.

Family PALMACEÆ.

A few specimens of palms collected were sent to the late Dr. Beccari for determination; unfortunately he did not have time to identify the material before his death. The following species were observed but no specimens collected.

Areca Catechu Linn. Occurs either cultivated or semi-wild practically throughout the territory.

Nipa fruticans Wurmb. Bail. Rep. Visit B.N.G., 28. Common along the Ethel River and its tributaries (Mekeo District).

Metroxylon Rumphii Mart. (*Sagus Rumphii* Willd.) Sago Palm.

Beccari in D'Albertis' "New Guinea," ii, 399, records *M. Rumphii* from the Fly River. Sago palms are common along the coast, and I also saw several along the edges of a small lake below Hombrom Bluff (Astrolabe Range). I did not collect specimens but have placed it under the above species.

Cocos nucifera Linn. Coconut. Extensively planted about villages around the coast.

Family ARACEÆ.

Epipremnum Zippelianum (Schott.) Engl. Becc. Malesia i. 274, tab. xx. pp. 10-12. Diene.

Family FLAGELLARIACEÆ.

Flagellaria indica Linn. F. Muell Pap. Pl. i (iv), 73; Rendle in Britt. Journ. Bot., xxiv, 358; Bail. Queens. Agric. Journ., iii, 161, and Rep. Visit B.N.G., 28. Dilava; [Samarai, *W. E. Armit.*]

F. indica, Linn., var. **minor** (Bl.) Hook. f. Bail. Queens. Agric. Journ., xxiii, 219. Port Moresby; Laloki River; Mt. Warirata; Astrolabe Range.

With the Mt. Warirata and Laloki River plant is the following note:—"The common and larger typical *F. indica* also present but not collected."

Family COMMELINACEÆ.

Pollia macrophylla Benth. Deva Deva and Mafulu.

Commelina nudiflora Linn. Mekeo District.

Aneilema nudiflorum R. Br. *Commelina ensifolia* Bail. Queens. Agric. Journ., xxii, 150 (*non* R. Br.). Boku, *Mrs. H. P. Schlencker.*

Mrs. Schlencker's specimens, referred by Bailey l.c. to *C. ensifolia*, I think are more correctly referable to the above.

Forrestia hispida Less. and A. Rich. Fofofofo.

For the determination of this plant I am indebted to Mr. H. N. Ridley, C.M.G., F.R.S.

Cyanotis capitata C. B. Clarke. Ridl. in Journ. Bot., xxiv, 358. Deva Deva.

FAMILY LILIACEÆ.

Rhipogonum papuanum sp. nov.

Frutex alte scandens inermis glaberque; foliis breviter petiolatis angusto-ellipticis ca. 13-17 cm. longis et 3·5-4·5 cm. latis coriaceis longe et obtusiuscule acuminatis trinervis transversis et valde reticulatis, racemis axillaribus et simplicibus vel terminalibus et paniculatis; floribus pedicellatis.

A tall glabrous climber, branchlets unarmed. Leaves opposite, sub-opposite, or alternate, narrowly elliptical, tapering at the apex into a rather long blunt point, prominently trinerved and reticulate on both faces; petiole often twisted, 3-6 lines (·7-1·3 cm.) long; lamina $4\frac{3}{4}$-$6\frac{3}{4}$ in. (12-17 cm.) long, $1\frac{1}{4}$-$1\frac{3}{4}$ in. (3-4·5 cm.) broad. Racemes in the upper axils, about $1\frac{1}{2}$ in. (4 cm.) long, bearing 2-4 (mostly 4) flowers towards the top; the upper racemes forming a terminal panicle $2\frac{1}{2}$-6 in. (6·5-15 cm.) long, branches often subtended by a narrow bract, up to [illegible] in. (1·8 cm.) long; flowers on slender pedicels of 2-5 lines (·3-1·1 cm.) long. Perianth unknown. Ovary glabrous.

Between Kubunah and Fofofofo.

The specimens are in young fruit only. In many ways it approaches the North Queensland *R. album* R. Br., var. *leptostachya*, from which, however, it differs in its longer more strongly veined leaves. Judging from the description it comes very near *R. Danesii* Domin, but differs from that species in its larger leaves, pedicellated flowers, and in the upper racemes forming a large terminal panicle. The genus has not apparently been previously recorded from New Guinea. There appear to be several forms of *R. album*, perhaps representing distinct species, in Queensland, but the material at my disposal is generally of too fragmentary a nature to base any critical work on.

Dracæna angustifolia Roxb. Becc. in D'Albertis' "New Guinea," ii, 399; F. Muell. Pap. Pl., i (iv), 73; Ridl. Journ. Bot., xxiv, 357. Astrolabe Range and Sogeri.

Cordyline terminalis Kunth. F. Muell Pap. Pl., i (ii), 30; Ridl. Journ. Bot., 24, 358; Bail. Rep. Visit B.N.G., 28; *Dracæna terminalis* Linn. Becc. in D'Albertis' "New Guinea," ii, 399. Mafulu.

Dianella cærulea Sims. Mt. Warirata.

D. ensifolia Red. F. Muell Pap. Pl., i (vi), 17; Ridl. Journ. Bot., 24, 358; F. Muell. Austr. Scientific Magazine, Oct. 1885; *D. nemorosa* Lam.; Hemsl. Kew Bulletin, 1899, 113. Mafulu.

Family MUSACEÆ.

(H. N. Ridley, C.M.G., M.A., F.R.S.)

Heliconia Micholtzi Ridl. Sogeri (No. 826).

Family ZINGIBERACEÆ.

(H. N. Ridley, C.M.G., M.A., F.R.S.)

Riedelia Whitei Ridl. (n. sp.).

Planta glabra gracilis ultra 30 cm. alta. Folia lanceolata acuminata basi longe angustata 18 cm. longa 3 cm. lata, petiolo gracili 2 cm. longa, ligula brevis glabra truncata 2 mm. longa vagina 6 cm. longa striolata haud cancellata. Racemus simplex 5 cm. longus vel ultra, decurvus terminalis, floribus ad 12 pedicellis 2 mm. longis. Calyx tubulosus cylindricus 15 mm. longus, ore obliquo lamina ovali. Corollæ tubus æquilongus, lobus superior elongata 7 mm. longus lanceolata acuminata in acumine longo, laterales multobreviores lineari oblonga 5 mm. longus. Labellum brevius, bifidus lobis lanceolatis acuminatis. Capsula oblongo elliptica rubra bilocularis in valvis 2 deh scens 1 cm. longa, 5 mm. crassa. Semina plurima aurantiaca.

Deva Deva (White, 655, 613).

Only one flower in moderate condition unfortunately, and that with the stamen decayed. The upper corolla-lobe has a peculiarly long acuminate point. The fruiting specimen No. 613 probably is of the same species. The fruits are peculiar from their dehiscing in 2 valves leaving a mass of very small-angled seeds in the centre.

Hornstedtia lycostoma Schum. Sogeri. 405.

Bracts red on edges, white-spotted on general ground area, white at base.

Riedelia lanatiligulata Ridl. (n. sp.).

Caulis validus 2 cm. crassus. Folia lineari-lanceolata acuminata basi angustata; superne hirtula; subtus molliter hirta margine sericea 60 cm. longa 9·5 cm. lata; petiolo canaliculato 8 cm. longa, vaginis cancellatæs hirtis vel subglabrescens, ligula maxima ovata 6-7 cm. longa 2 cm. lata dense

longo-lanuginosa. Panicula lateralis valida : ramis 3 multi floris 13 cm. longis. Bracteæ ad bases ramorum lineari-lanceolatæ papyraceæ 15 cm. longæ 1·5 cm. latæ. Flores subsessiles glabri. Bracteola calyciformis tubulosa costata ad basin angustata breviter tridentata ; 10 mm. longa. Calyx 17 mm. longa cylindrica costata, in uno latere fissa, dentibus 2, acuminatis. Petala angusta linearia, tubo calyce æquilongo. Labellum profunde bifidum in lobis linearibus 2. Stylus filiformis ad apice gradatim incrassatis, stigmate obconico.

Near Fofofofo (No. 615).

This species is very distinct in its hairy leaves and very large woolly ligule, and is apparently a very robust plant. Unfortunately the few buds which are left on the specimen are in a very rotten condition.

Tapeinocheilos pubescens Ridl., Journ. Bot., xxiv. 356. Sogeri (No. 313).

Costus speciosus Sm. var. **argyrophyllus** Wall. Sogeri (No. 414). Flowers white ; apparently identical with *C. Lamingtonii* Bail.

Eriolopha ovalifolia Ridl. (n. sp.).

Caulis 62 cm. longæ. Folia ovata acuminata rigida, basi rotundata 9 cm. longa 3 cm. lata, petiolo 4 mm. longo, vagina 3 cm. longa cancellata ligula brevi 3 mm. longa cum marginibus vaginæ pubescenti. Racemus terminalis simplex 13 cm. longus velutino-pubescens. Bractea ad basin linearis lanceolata acuminata 8 cm. longa 5 mm. lata glabra. Pedicelli 3 mm. longi velutini ad 14. Calyx tubulosa 14 mm. longæ cylindrica lamina ovata pubescens. Corolla tubo calyce æquante. Petalum superius oblongum-ovatum obtusum cucullatum 5 mm. longum pubescens, lateralia angustiora pubescentia obtusa. Labellum multibrevius bifidus ad medium, lobis ala tenui rotundata exteriore, nitus processu lineari-obtuso incrassato. Anthera glabra oblonga truncata retusa, crista nulla stylus gracilis glaber. Stilidia minuta.

Deva Deva (White, 656).

This species is peculiar in its ovate rigid leaves and apparently complete absence of anther-crest, in spite of which it appears to be in other respects an *Eriolopha*. The stamen is notched at the top, the anther-cells projecting as two short

points. The lip is as usual very small, and deeply bifid, each lobe consisting of a thin outer rounded wing while the inner edge is more fleshy and prolonged into a short blunt point.

Owing to the poorness of the material to hand several other specimens of Zingiberaceæ could not be specifically determined.

Family MARANTACEÆ.

(H. N. Ridley, C.M.G., M.A., F.R.S.)

Donax cannæformis Ridl. Sogeri. Common all over the eastern islands.

Cominsia Guppyi Hemsl. Between Sogeri and Javararie. I am inclined to agree with Schumann that *Cominsia Guppyi* Hemsl. and *C. gigantea* are the same species.

Phrynium capitatum Willd. Sogeri. A common plant. In fruit only. The species is recorded from India, Cochin China, China, and Java, but I am doubtful as to whether the Malay plant is not distinct from the Indian one.

Phacelophrynium Whitei Ridl. (n. sp.)

Caules gracilis 30 cm. longis vel ultra. Folium lanceolatum acuminatum basi subacuto subinæquilaterum 24 cm. longum. 7·5 cm. latum petiolo 10 cm. longo. Pedunculus 10 cm. longus gracilis panicula 6 cm. longa; ramis paucis congestis. Bracteæ lanceolatæ siccæ 8 mm. longa, vel minora. Flores parvi verosimiliter albi, pedicellis 2 mm. longis ad 1 cm. crescentibus. Ovarium oblongum pubescens 1 mm. longum. Sepala 3 mm. longa late lanceolata acuminata. Corolla tubo sepalis æquilongo lobis late oblongis obtusis, recurvis. Labellum obovatum rotundatum, integrum. Anthera linearis.

Mekeo District (807).

A small-sized plant with a short many-spiked dense panicle. The whole flower 1 cm. long. Allied to an undescribed Borneo species. Though the inflorescence in these plants is much smaller than in typical *Phacelophrynium*, I think that as far as its structure goes it is best to keep them in this genus.

The collection also includes specimens of some other Marantaceæ which owing to poorness of material could not be specifically determined.

Monophrynium sp. Mafulu (420). A fruiting specimen of a large plant with broad cut-up leaves as in *Phrynium fissifolium* Ridl. The fruit resembles that of *Monophrynium fasciculatum* Schum., but is less acutely angled. The specimen is too

incomplete (all the bracts having fallen) to describe adequately, but it is evidently an undescribed plant allied to *Monophrynium* and *Cominsia*.

Phacelophrynium sp.

Caules graciles 60 cm. alti. Folium lineari-oblongum; valdevenosum costa alte elevata basi cuneato 32 cm. longum 6 cm. latum, petiolo 18 cm. longo. Panicula brevis 8 cm. longa, pauce ramosa. Bracteæ tenuiter papyracea lanceolata acuminata 3 cm. longa 5 mm. lata. Flores non visi. Panicula fructifera ramis validulis 4 cm. longa 5 cm. lata. Capsula obtuse triquetra globosa 1 cm. longa et lata.

Deva Deva (632); Central Division (825).

This species is notable for the prominence of the nerves, especially on the back of the leaf when dry, and the small size of the few-branched panicle with the thin lanceolate brown bracts.

The collection also contains another more typical *Phacelophrynium* with large leaves and a panicle of 3 branches 15 cm. long of distichous stout bracts 3-4 cm. long, 2 cm. wide, in which are smooth, polished, yellow, triquetrous capsules 1·5 cm. long in pairs on very short peduncles. It is to be hoped that complete specimens of this fine plant may be obtained. Sogeri (No. 406).

Family ORCHIDACEÆ.

A complete account of the Orchidaceæ collected has already been published under the joint authorship of Dr. R. S. Rogers, M.A., and myself in the "Transactions and Proceedings of the Royal Society of South Australia," vol. xliv, pp. 110-119, plates v-viii.

DICOTYLEDONEÆ.

Family CASUARINACEÆ.

Casuarina nodiflora G. Forst. F. Muell. Pap. Pl., ii (vi), 6. Astrolabe Range and Mafulu District. A very common tree in the first-mentioned locality.

C. equisetifolia R. & G. Forst. F. Muell. Pap. Pl., i (i) 12; Bail. Rep. Visit B.N.G., 28, and Queens. Agric. Journ., xxii, 149; Foxworthy Ann. Rep. Papua, 1909-10, 114. I did not see this growing wild, but there is a fine avenue of these trees planted along the esplanade road at Port Moresby.

Family PIPERACEÆ.

Piper miniatum Bl. Bisiatabu. A climbing Pepper with long red fruiting-spikes.

Family FAGACEÆ.

(Order Cupuliferæ.)

Quercus sp. Deva Deva.

Castanopsis Schlenckeræ Bail., Queens. Agric. Journ., xxii, 149. Mafulu. Large tree, dense foliage, common.

Family ULMACEÆ.

Trema virgata Bl., var. **scabra** Bl. Lauterbach Beitr. Fl. Pap., iii, 312; (*T. cannabina* F. Muell. Pap. Pl., i (iii), 40; *T. aspera* Bl., var. *viridis* (Bl.) Benth.). Port Moresby.

Family MORACEÆ.

Fatoua japonica Bl. Yule Island; Port Moresby, *E. Cowley*.

Cudrania javanensis Trécul. Laloki River.

Artocarpus incisa Forst. Becc. in D'Albertis' "New Guinea," ii, 398; Bail. Rep. Visit B.N.G., 27. Port Moresby; Laloki River; Mekeo District; Yule Island. Not collected, but common wild or cultivated through the whole of the coastal country.

Ficus infectoria Roxb. Sapphire Creek.

F. Rigo Bail., Queens. Agric. Journ., i, 235. Yule Island. A handsome tree, much planted about Port Moresby.

F. retusa Linn. Yule Island. For ornamental planting this tree is one of the very best of the Figs, having a great spread of dense dark-green foliage.

[**F. fistulosa** Reinw. Ambasi, *Rev. Copland King*; S.E. New Guinea, *H. O. Forbes* (ex Nat. Herb. Melb.); Sogeri, *H. O. Forbes* (ex Nat. Herb. Melb.)]

F. myriocarpa Miq. Javararie.

It is with some hesitation that I refer these specimens to *F. myriocarpa*; the leaves are densely hirsute but scarcely hispid and certainly not hispid on both surfaces. The identification wants confirming with better material.

Family URTICACEÆ.

Elatostemma lineolatum Wight, var. **integrifolium** Hook. Between Sogeri and Javararie; Dilava; Mafulu.

E. sesquifolium Hassk. Bisiatabu (Astrolabe Range). A form with the leaves pubescent on both upper and lower surfaces.

E. sessile Forst. Dilava.

My collection also contains several other species of *Elatostemma*, but in too bad a state for determination.

Pouzolzia hirta Hassk. (*P. quinquenervis* Benn.). F. Muell. Pap. Pl., i (iii), 40. Mafulu.

Pipturus incanus (Bl.) Wedd. (*P. velutinus* Wedd.) Becc. in D'Albertis' "New Guinea," ii, 398; F. Muell. Pap. Pl., i (iv), 60; (*P. argenteus* Bail., Queens. Agric. Journ., xxiii, 219 (*non* Willd.)). Port Moresby.

I follow Mueller and others in keeping the Papuan plant as *P. incanus*; in general appearance, however, it can hardly be distinguished from the common Australian *P. argenteus*. All my specimens and Mrs. Schlencker's, referred to *P. argenteus* by Bailey l.c., are slightly scabrid on the upper surface of the leaves.

Leucosyke capitellata Wedd. Dilava.

Family PROTEACEÆ.

Grevillea pinnatifida Bail., Occasional Papers on the Queensland Flora, 6 (1886); *G. Edelfeldtiana* (name only) F. M. in Vic. Nat., Feb. 1885, and Pap. Pl., 2 (vi), 9; Lauterbach, Beitrage zur Flora Papuasien, iii, 329. Astrolabe Range (very abundant).

This tree is very abundant on the Astrolabe Range and averages 30-40 ft. high. I was unable, however, to gather either flowers or fruits, and Mueller named his *G. Edelfeldtiana* from leaves only. The leaves, however, are exactly those of the North Queensland *G. pinnatifida*, and consequently I have reduced Mueller's name to a synonym. Mueller's name had a year's priority over Bailey's, but as it was unaccompanied by a description of any sort it should lapse in favour of the latter. I am indebted to Prof. A. J. Ewart for having compared my Papuan material with Mueller's type in the National Herbarium at Melbourne.

G. subargentea sp. nov.

Arbor mediocris, ramulis junioribus sericeo-pubescentibus; foliis junioribus ca. 30·5 cm. longis alte 3-5 lobatis, lobis 1·2-2·5 cm. latis, subtus sericeo-pubescentibus; foliis

maturis integris vel breviter lobatis, lanceolatis vel falcato-lanceolatis, subtus sericeo-pubescentibus utrinque reticulatis subtriplinervis racemis ca. 16·5 cm. longis; floribus ignotis; fructu ellipsoideo, ca. 2·5 cm. longo.

A medium-sized tree, the very young parts clothed with white appressed hairs. Leaves on coppice shoots or young trees deeply pinnatifid into 3-5 lobes, about 1 ft. (30·5 cm.) long, the individual lobes $\frac{1}{2}$-1 in. (1·2-2·5 cm.) broad; adult foliage entire or slightly lobed, lanceolate, sometimes somewhat falcate, tapering at the base into a petiole of 6-8 in. (15-20 cm.) long, varying in width from 1-$2\frac{3}{4}$ in. (2·5-7 cm.), under surface silky pubescent; both faces in the dried specimens prominently reticulate with very oblique veins and veinlets, a pair of secondary veins running parallel with the midrib about half-way between it and the edge of the leaf. Racemes (only seen in fruit) up to $6\frac{1}{2}$ in. (16·5 cm.) long. Flowers unknown. Follicle woody, ellipsoid, slightly compressed, not stipitate, 1 in. (2·5 cm.) long, 7-8 lines (1·5-1·8 cm.) broad on a pedicel of 2 lines (5 mm.).

Deva Deva (Nos. 643 and 653).

In systematic position this species comes between the East Australian *G. pinnatifida* and *G. Hilliana*.

[**G. densiflora** sp. nov.

Arbor, ramulis robustis; foliis petiolatis, petiolo pubescente, lanceolatis vel obovato-lanceolatis supra glabrescentibus, subtus minute lepidotis, nervis lateralibus circiter 20 ante marginem conjunctis, juxta marginem nervo altero marginati unitis; racemis simplicibus axillaribus densifloris cum pedicellis et floribus ferrugineo-pubescentibus; pistilo glabro ovario stipitato.

A tree, branchlets stout. Leaves petiolate, petiole about 8 lines (1·7 cm.) long, clothed with an appressed pubescence; blade $4\frac{1}{2}$-$8\frac{1}{2}$ in. (11·5-30·7 cm.) long, about 2 in. (5 cm.) wide, lanceolate or obovate-lanceolate, upper surface glabrescent, under surface densely covered with minute gland-like scales, both faces reticulate; the midrib and main nerves prominent, main lateral nerves about 20 on each side of the midrib, about 1-$1\frac{1}{2}$ line (2-3 mm.) from the margin arching into a prominent intramarginal vein. Racemes very densely flowered, about as long as the leaves, rhachis densely pubescent with appressed somewhat strigose

hairs. Pedicels 3-4 lines (6-9 mm.) long, pubescent with somewhat strigose hairs. Perianth segments 4 lines (9 mm.) long, clothed on the outer surface with appressed strigose hairs. Pistil glabrous; ovary stipitate on a gynophore 1½ line (3 mm.). Fruit not seen.

Boku, British New Guinea, *Mrs. H. P. Schlencker.*

This new species is quite unlike any other Papuan or Australian *Grevillea* known to me. The specimens were collected by Mrs. Schlencker in 1909 and referred by the late F. M. Bailey as near *Finschia rufa* Warbg. It may, when the fruit is known, prove a species of *Finschia*, but it differs from *F. rufa* and *F. chloroxantha*, the only known members of the genus.]

Helicia validinervis sp. nov.

Arbor, ramulis glabris; foliis petiolatis lanceolatis sensim longe acuminatis integris utrinque glabris reticulatis nervis subtus prominentibus; racemis laxifloris rhachide pubescente; floribus geminatum pedicellatis pedicello dense pubescente; perianthii segmentis ferrugineo-pubescentibus; ovario hirsuto, stylo glabro.

A tree, branchlets glabrous, finely striate. Leaves distinctly petiolate, petiole ½-1 in. (1·3-2·5 cm.); blade lanceolate, tapering at the apex into a long acuminate point, 7-11½ in. (18-29 cm.) long, glabrous, green on both faces, strongly nerved, main nerves prominently raised on the under surface, reticulations distinct between them, margins entire. Racemes shorter than the leaves, about 7 in. (18 cm.) long, rhachis clothed with rather long, scattered, ferruginous hairs. Flowers on pedicels of about 1 line (2 mm.); pedicels and perianth segments ferruginous-pubescent, ovary densely clothed with long villous hairs.

Mekeo District.

Among previously recorded Papuan species *H. validinervis* approaches very closely to *H. toricelliensis* Laut., which differs from it in its smaller leaves insensibly tapering at the base into a petiole. From *H. Forbesiana* it differs in its larger flowers and smaller less prominently veined leaves. Lauterbach's key to the Papuan species of *Helicia* (Beiträge zur Flora von Papuasien, iii. 330) places *H. Forbesiana* among those with a glabrous rhachis, whereas specimens from the National Herbarium, Melbourne, and collected by Forbes, show the rhachis to be clothed with scattered ferruginous hairs.

H. latifolia sp. nov.

Arbor, ramulis lenticellatis; foliis utrinque glabris prominule reticulatis supra nitidis late lanceolatis vel elliptico

lanceolatis integris breviter petiolatis, petiolis incrassatis; racemis laxifloris, floribus pedicellatis, pedicellis ferrugineo-pubescentibus; perianthii segmentis 9 mm. longis fere glabris; pistillo glabro.

A tree, branchlets lenticellate. Leaves shortly petiolate, petiole stout, 1-3 lines (2-6 mm.) long; blade broadly lanceolate, glabrous on both sides, veins and reticulations fairly prominent, upper surface rather glossy, apex bluntly acuminate, 5-8 in. (13-10·7 cm.) long, 2½-4¼ in. (6·5-11 cm.) broad, margins entire. Racemes about as long as or longer than the leaves; rhachis clothed with a few ferruginous hairs. Flowers in pairs but pedicels distinct to the base, pedicels 1½-2 lines (3-4 mm.) long, thinly ferruginous-pubescent. Perianth 4 lines (9 mm.) long, glabrous except for a few brown hairs on the outer surface. Ovary and style glabrous.

Deva Deva.

Amongst previously recorded Papuan species *Helicia latifolia* approaches most closely to *H. moluccana*, which differs in its quite glabrous inflorescence and narrower leaves.

Banksia dentata Linn. f. F. Muell. Pap. Pl. (ii), 28; Beccari in D'Albertis' "New Guinea," 2, 398; Lauterbach in "Beiträge zur Flora von Papuasien," iii, 334. Astrolabe Range (very common).

FAMILY LORANTHACEÆ.

(By W. F. Blakely, Botanical Assistant, National Herbarium, Sydney.)

LORANTHUS L.

Subgenus I.—EULORANTHUS Engl.

Section I.—DACTYLIOPHORA van Tiegh.

Series I.—EUAMYEMA Engl.—B. CYMULATI.

Loranthus barbellatus Blakely n. sp.

Glaber; ramis robustis nodis subtumidis; foliis oppositis late spathulatis; vel ellipticis, petiolatis, coriaceis, 5-7 nerviis, 3-9 cm. longis, 2-5 cm. latis; cymis interaxillaribus, foliis brevioribus, 3-6 ramis; floribus in triadibus, intermediis sessilibus; pedunculo communi tenue, 15 mm. longo; pedicellis 5-7 mm. longis; calyce lato cupulare irregulariter denticulato;

alabastris cylindraceis 25 mm. longis; petalis liberis 5-6 apice barbatis; antheris linearibus adnatis 4 mm. longis, fructus non vidimis.

Glabrous shrubs, branches rather stout, nodes somewhat prominent or swollen; leaves opposite, broad spathulate to broadly elliptical, undulate, tapering into a short stout petiole, 6-9 cm. long, 2-5 cm. broad, somewhat coriaceous, 5-7-nerved, the second pair confluent with the median nerve 1-3 cm. from the base, the upper portion branched, spreading, flexuose or looped. Cymes internodous, single or in pairs, shorter than the leaves; common peduncle slender, 15 mm. long, 3-6-branched; flowers arranged in triads, the middle one of each triad sessile, the two lateral on short pedicels. Bracts broad lanceolate, concave acute, 2 mm. long, minutely ciliate at the apex, shorter than the calyx. Calyx broadly cupular, irregularly denticulate. Buds slender, cylindrical, 25 mm. long; petals 5-6, free, narrow-lanceolate, bearded on the inside with a tuft of red-brown semi-deciduous hairs. Filaments narrow, 4-5 mm. long; anthers adnate, linear, 4 mm. long. Style angular, broader towards the base, 27 mm. long; stigma small, capitate. Disc prominent. Fruit not seen.

Astrolabe Range, on *Eucalyptus* (No. 231).

As far as I am aware this species does not appear to answer the description of any previously described species, and I therefore propose the name *L. barbellatus* on account of the petals being bearded inside at the apex. Its nearest affinity is *L. queenslandicus* Blakely MSS., from which it differs in the more strongly marked venation and undulate leaves, different shaped calyx, bracts, and relatively smaller and finer pedicels, also in the domed disc. The filaments of *L. queenslandicus* are twice the length of the anthers, those of *L. barbellatus* are about the same length. The inflorescence, the only one I saw *in situ*, is internodous. Whether this is a constant character remains to be proved, as I have not seen it in any of the Australian species investigated by me. This species resembles somewhat *L. novæ-guineæ* Bail. in the foliage, but the inflorescence is not the same.

Subgenus II.—Dendrophthœ Mart.

L. odontocalyx F. v. M., var **propria** Blakely var nov.

Vestimentum surculorum juvenilium atque inflorescentiæ minute rufro-cinereum. Folia macro plerumque late lanceolata, 5-10 cm. longa, 2-5 cm. lata, petiolata; petiolæ 1-2 cm. longæ.

Vestiture of the young shoot and the inflorescence minutely

rufous-hoary. Leaves thin, usually broad-lanceolate, 5-10 cm. long, 2-5 cm. broad, petiolate ; petioles 1-2 cm. long. Inflorescence and structure of the flowers the same as *L. odontocalyx*, but the calyx is often entire, sometimes split on one side, and minutely and irregularly toothed.

Yule Island, on *Inocarpus edulis*, "Corolla tube yellow ; lobes red." (No. 736.)

This variety is intermediate between *L. odontocalyx* F. v. M. and *L. vitellinus* F. v. M. It has some of the characters of both, and yet dissimilar. The typical *L. odontocalyx* has a hoary vestiture, whilst the vestiture of *L. vitellinus* is ferruginous tomentose. That of the new variety is partly both.

II.—VISCOIDEÆ.

Viscum.

Section I.—Ploinixia Korth.

Series I.—Isanthemum van Tiegh.

Viscum verruculosum Wight et Arn. in Fl. Ind. Ori., i, 279. Yule Island (No. 720). Fruit immature, cylindrical, contracted at the base, prominently verrucose.

This specimen agrees somewhat with *V. orientale* Willd., as figured in Blume's Flora Java, t. 24, but it is more applicable to the description of *V. verruculosum*, especially in the shape and character of the fruits, as will be seen presently. J. D. Hooker, in Flora British India, v, 224, describes the fruits of *V. orientale* Willd. as "globose, smooth." Kurz. in Forest Flora, British Burma, ii, 324, states that they are "globular, the size of a pea." Wight in Illustrations of Indian Botany, p. 68, pl. 122, depicts a smooth elliptical fruit, while in his Fl. Ind. Ori. l.c. he describes the fruits as "(purple) somewhat globose, copiously and minutely dotted." In the same work the fruits of *V. verruculosum* are described thus :—"Berries (very immature) linear-oblong, covered with little warts."

There is a footnote which runs—"Dr. Wight made the following memorandum when he collected the specimen : Fruit long, slender, warty, lateral ones of each fascicle cernuous, leaves and plant very like *V. orientale*, of which it is perhaps a variety. Keeble in the Loranthaceæ of Ceylon, Trans. Linn. Soc. Lond., 2nd ser., Botany, vol. v, pt. iii, p. 115 (1896), describes the fruits of *V. orientale* as "small green, somewhat lenticular with oval outline."

Trimen in Handbook Flora Ceylon, iii, 471, is inclined to the opinion that the Ceylon plant which has "much warted fruits" is *V. verruculosum* W. & A.

It appears to me that further investigation will prove this to be a valid species. The new locality is an extension to its previously known range, and the species is an addition to the Flora of New Guinea.

Section II.—Aspidixia Korth.

V. angulatum Heyne. Astrolabe Range (No. 344).

As far as I am aware this species has not been recorded previously for the mainland of New Guinea. It has an extensive Oceanic range, extending from India to the Philippine Islands, New Guinea, Thursday Island, Prince of Wales Island, and thence to Australia.

Family SANTALACEÆ.

Exocarpus latifolia R. Br. F. Muell. Pap. Pl., 1 (1), 10. Port Moresby.

Family OLACACEÆ.

Opilia amentacea Roxb. F. Muell. Pap. Pl., i (iv), 53. Yule Island.

Cardiopteris moluccana Blume. *C. lobata* Bail. Queens. Agric. Journ., xxiv, 20 (*non* R. Br.). Yule Island.

Family ARISTOLOCHIACEÆ.

Aristolochia Tagala Cham. Sogeri.

My specimens are in fruit only but agree well with specimens of this Philippine plant received from the Bureau of Science, Manila, P.I.

Family POLYGONACEÆ.

Polygonum barbatum Linn. F. Muell. Pap. Pl., i (iv), 58. Sogeri. A glabrescent form.

P. chinense Linn. Hemsl. Kew Bulletin, 1899, 108. Mafulu.

P. alatum Buch., var. **nepalense** Hook. f. Bella Vista (about 5,000 feet).

Family AMARANTACEÆ.

Amarantus viridis L. Port Moresby. A common weed.

Cyathula prostrata Blume. (C. *geniculata* Lour). Javararie.

Family CARYOPHYLLACEÆ.

Drymaria diandra Bl. F. Muell. Pap. Pl., i (v), 86. Javararie. A common weed along damp plantation tracks.

Family RANUNCULACEÆ.

Clematis Pickeringii A. Gr. Sogeri.

FAMILY ANONACEÆ.

[**Uvaria purpurea** (Bl.) var. **neoguineensis** (Engl.) Diels. (*U. neoguineensis* Engl.) Boku, *Mrs. H. P. Schlencker.*]

Eupomatia laurina R. Br. F. Muell. Pap. Pl., ii (vii), 26. Astrolabe Range.

Several other Anonaceæ were collected, but as they are in fruit only it is impossible to trace the species down; there are also several other Papuan Anonaceæ in the Queensland Herbarium in like condition.

FAMILY MYRISTICACEÆ.

Myristica subalulata Miq. Warb. Monogr. Myristic., 486. Sogeri District; Mafulu.

FAMILY LAURACEÆ.

Litsea calophyllantha K. Sch. Dilava.

My specimens are in fruit only but the leaves agree well with specimens collected by Dr. Karl Weinland. The fruits (not previously described) are—Elliptic, about 1 in. (2·5 cm.) long and ½ in. (1·2 cm.) long, seated on the slightly enlarged calyx.

Cryptocarya triplinervis R. Br. Yule Island.

Differs from the typical Australian *C. triplinervis* in the under surface of the leaves only being thinly pubescent with tufts of hairs in the axils of the primary veins. Some North Queensland specimens are inclined to be glabrescent but not to so marked a degree as the Papuan plant. My specimens are in fruit only and when better known the Papuan plant may be found worthy of varietal or even specific distinction.

Cassytha pubescens R. Br. Port Moresby.

My specimens are more or less densely pubescent, even on the older stems.

[**C. filiformis.** British New Guinea—without precise locality, Sir Wm. Macgregor.]

In addition to the above my Lauraceæ material includes three species of *Cinnamomum* in leaf only; one of these—a large tree from Sogeri—possesses a bark with a very strong cinnamon-like odour.

FAMILY CAPPARIDACEÆ.

Polanisia viscosa DC. F. Muell. Pap. Pl., i (iv), 52; Bail. Rep. Visit B.N.G., 27. Port Moresby.

Capparis umbellata R. Br. Port Moresby; Yule Island.

C. quiniflora DC. F. Muell. Pap. Pl., i (i), 5; Lauterbach Beitr. Fl. Pap., iv, 112. Port Moresby.

C. lucida R. Br. Port Moresby.

Mueller has recorded *C. nobilis* as a Papuan plant, and my collections include two other species, but both too fragmentary to name specifically.

FAMILY NEPENTHACEÆ.

Nepenthes Kennedyana F. Muell. F. Muell. Pap. Pl., i (ii). 20; Bail. Rep. Visit B.N.G., 28; Bail. Queens. Agric. Journ., xxii, 148 Astrolabe Range. A climber in swampy ground round edge of a small lake below Hombrom Bluff.

My specimens bear male flowers only; the spikes are more slender and the flowers not so crowded as in the typical plant; it may when fruit are available prove distinct. Mrs. Schlencker's specimens referred to by Bailey l.c. are in fruit and typical.

N. Moorei Bail. Astrolabe Range. Very common in dry open forest country near Bisiatabu. The specimens seem to agree well with the Australian plant.

FAMILY PITTOSPORACEÆ.

Pittosporum ferrugineum Ait. F. Muell. Pap. Pl., ii (vi), 4; Vic. Nat. April 1885; Bail. Queens. Agric. Journ., ix, 410. Mafulu.

FAMILY ROSACEÆ.

Rubus moluccanus Linn. Hemsley Kew Bull. 1899, 99; Bail. Queens. Agric. Journ., xxii, 148, and xxiii, 220. Astrolabe Range and Mafulu.

R. rosæfolius Sm. Hemsley Kew Bull. 1899, 99; F. Muell. Pap. Pl., ii (vii), 29; Bail. Queens. Agric. Journ., xxiii, 220. Astrolabe Range and Mafulu.

FAMILY LEGUMINOSÆ.

Albizzia procera Benth. Bail. Rep. Visit B.N.G., 28. Port Moresby. A very common tree.

Acacia farnesiana Willd. Port Moresby. Fairly common, perhaps naturalised.

A. auriculæformis A. Cunn. Port Moresby. Fairly common.

Afzelia bijuga A. Gray. Bail. Queens. Agric. Journ., vii, 348. Laloki River; Yule Island. The timber, locally known as "Melila," is the principal hardwood of the territory.

Bauhinia sp. Port Moresby. A scrambling shrub; leaflets free to the base, obliquely oblong, about $1\frac{1}{2}$ in. (4 cm.) long and about 1 in. (2·5 cm.) broad. Pods thick and woody. Probably represents a new species but the flowers are unknown.

Cassia alata Linn. Ringworm Bush. Naturalised and very common about Port Moresby.

Cæsalpinia Bonducella Roxb. Port Moresby. It is recorded by Mueller in Pap. Pl., i (iii), 43, from Darnley Island. This, however, is Queensland territory.

C. nuga Ait. Bail. Rep. Visit B.N.G., 28; Proc. Roy. Soc. Queens., xviii, 1. Yule Island.

Crotalaria juncea Linn. F. Muell. Pap. Pl., i (iv), 61. Port Moresby.

C. linifolia Linn. f. F. Muell. Pap. Pl., i (iii), 42; Bail. Rep. Visit B.N.G., 27. Port Moresby.

C. calycina Schranck. Sapphire Creek.

C. striata DC. Port Moresby.

I saw this plant growing about the town but omitted to gather specimens.

Psoralea badocana (Blanco) Benth. Port Moresby; Yule Island. This rather pretty blue-flowered plant is very abundant at the localities mentioned.

Indigofera linifolia Retz. F. Muell. Pap. Pl., i (iii), 42. Yule Island.

I. enneaphylla Linn. F. Muell. Pap. Pl., i (iv), 61. Port Moresby.

I. trifoliata Linn. F. Muell. Pap. Pl., i (iii), 42. Sapphire Creek.

I. viscosa Lam. F. Muell. Pap. Pl., i (iv), 61. Port Moresby.

Tephrosia vestita Vog. Sapphire Creek and Astrolabe Range.

T. astragaloides R. Br. *T. vestita* Bail. Queens. Agric. Journ., xxiii, 218 (*non* Vogel). Port Moresby.

A very common plant about Port Moresby. The flowers are whitish or with a faint purplish tinge and are borne in elongated racemes. The leaves are silky above, hence the Papuan plant would go under the variety (?) *macrostachya* Benth.; this variety, however, does not seem a very well-marked one. The specimen referred to by Bailey l.c. as *T. vestita* belongs here.

Sesbania aculeata Pers. F. Muell. Pap. Pl., i (iv), 62. Port Moresby.

Stylosanthes mucronata Willd. Port Moresby.

Very abundant in the streets and roads of the town area: probably introduced. In North Queensland this plant has attracted considerable attention as a fodder.

Desmodium umbellatum DC. F. Muell. Pap. Pl., i (iii), 42. Port Moresby (very common).

D. pulchellum Benth. F. Muell. Vic. Nat. Feb. 1885; Pap. Pl., ii (vi), 7. Sapphire Creek and Astrolabe Range.

D. gangeticum DC. F. Muell. Pap. Pl., i (v), 88. Sapphire Creek; Yule Island.

D. parvifolium DC. Sapphire Creek.

D. Scalpe DC. Mafulu.

D. triquetrum DC. F. Muell. Pap. Pl., ii (vi), 7. Astrolabe Range.

D. papuanum n. sp.

Fruticosa erecta, ramulis griseo-pubescentibus; foliis petiolatis, unifoliolatis vel raro trifoliolatis, foliolis oblongis utrinque pubescentibus, terminali maximo, lateralibus duplo vel triplo brevioribus: racemis terminalibus, rhachide pedicillisque ferrugineo-pubescentibus, floribus violaceis; bracteis late lanceolatis acuminatis striatis pubescentibus; leguminibus ferrugineo-pubescentibus, articulis 7-9.

An erect branching shrub about 3 ft. (1 m.) high. Branches woody, clothed with grey hairs, young branchlets densely so. Leaves usually 1-foliolate, sometimes 3-foliolate; petiole about ¾ in. (2 cm.) long, grey-pubescent; leaflets oblong, clothed on both faces with long silky hairs, particularly the under surface; single or end leaflet 1-1½ in. (2·5-4 cm.) long, ½-¾ in. (1·4-2 cm.) broad; side leaflets when present much smaller, about ½ in. (1·4 cm.) long and ¼ in. (7 mm.) broad; stipules 4 lines (9 mm.) long, silky-pubescent. Racemes terminal, 1-1½ in. (2·5-3·8 cm.) long, rhachis closely and densely ferruginous-pubescent; bracts hirsute with yellow hairs, broadly lanceolate, acutely acuminate, closely striate, about 5 lines (1·1 cm.) long and 2 lines (4 mm.) broad. Flowers blue-violet; pedicels ferruginous-pubescent. 2-3 lines (4-7 mm.) long; calyx about 1 line long; standard 5 lines (1·1 cm.) across; wings and keel

each 4 lines (9 mm.) long; ovary densely clothed with long white hairs. Pod about 1 in. (2·5 cm.) long, of 7-9 articles, ferruginous-pubescent with spreading hairs.

Astrolabe Range [Stephansort, bei Erima am Strande, *Lewandowsky* n. 62 am 20 Aug. 1899.]

Closely allied to *D. polycarpum* from which it is easily distinguishable by several features, as for instance its usually 1-foliolate leaves, pubescent non-striate stipules, more generally pubescent character, larger flowers, and larger ferruginous-pubescent pods. Lewandowsky's plant (referred by Schumann and Lauterbach in "Die Flora der Deutsche-Schutzgebiete in der Südsee" to *D. polycarpum*) I would refer here.

Alysicarpus vaginalis DC. Port Moresby (with oblong leaves); Yule Island (a form with very narrow-lanceolate leaves).

Uraria lagopoides DC. Mt. Warirata; Yule Island.

Phylacium bracteosum Benn. Javararie; Sogeri; Mafulu (a very common climber); [Boku, *Mrs. H. P. Schlencker.*]

Dalbergia densa Benth. Bail. Rep. Visit B.N.G., 28. Yule Island. A form with large leaflets, the leaflets up to 2¾ in. long and 1½ in. broad.

D. monosperma Dalz. Port Moresby. A common climber on the coast over mangrove trees, etc.

Derris uliginosa Benth. Yule Island. Known in Papua under the name of "Dynamite Plant" from its use by the natives as a fish-poison.

Inocarpus edulis R. & G. Forst. Bail. Ann. Rep. B.N.G. 1900-01, 142; Queens. Agric. Journ., xxii, 147. Yule Island.

Abrus precatorius Linn. F. Muell. Pap. Pl., i (iv), 62. Port Moresby.

Clitoria ternatea Linn. Port Moresby.

This pretty little climber is seen everywhere about the town, over the fences of the native gardens, etc. Flowers varying from almost white to very deep blue.

Glycine tomentosa Benth. Yule Island.

Erythrina indica Lam. Coral tree. F. Muell. Pap. Pl., ii (vi), 8; Bail. Rep. Visit B.N.G., 27, 28. Port Moresby; Yule Island.

Mucuna gigantea DC. Yule Island.

M. Kraetkei Warb. Schum. & Laut. Nachtr. Flora der Deutsch. Schutzg, Sudsee 278. Sogeri.

Fairly common; a most magnificent climber with brilliant scarlet flowers. This and *M. Bennettii* F. Muell. both go under the name of "D'Albertis' Creeper."

M. Stanleyi sp. nov.

Ramulis, ferrugineo-hirsutis; foliis longe petiolatis, foliolis amplis breviter petiolulatis subtus dense ferrugineo-pubescentibus suborbicularibus apice acuminatis lateralibus maxime obliquis, stipellis filiformibus, pannicula ferrugineo-hirsuta; calyce fere ad medium 4-lobo (bilabiato) tubo utrinque hirsuto, legumine 3-5 spermo, valvis lamellis obliquis imbricatis munitis.

A large forest climber, branchlets and petioles hirsute with long rust-coloured hairs. Leaflets nearly orbicular or lateral ones very oblique, apex acuminate, very thinly pubescent above, densely ferruginous-pubescent beneath, lateral ones 4-5½ in. (10-14 cm.) long, 5-5½ in. (12·5-14 cm.) broad, all on petiolules of about 3 lines (6 mm.); stipules absent (?), stipellæ filiform about 5 lines (1·1 cm.) long; length of petiole below the lateral leaflets about 3 in. (7·5 cm.) long, length of rhachis between the lateral leaflets and terminal one about ¾ in. (2 cm.). Panicle branches densely rufous-pubescent with long spreading hairs. Bracts ovate-lanceolate, acuminate, ¾-1 in. (2-3.2 cm.) long, clothed with long brown hairs. Calyx about 1 in. (2-5 cm.) long, 4-lobed (2-lipped), upper lip about 3 lines (6 mm.) long, lateral lobes of the lower lip 3 lines (6 mm.) long, lowest lobe about 6 lines (1·3 cm.) long, hirsute both inside and out with ferruginous hairs. Corolla whitish (rather imperfect in the dried specimens for dissection); standard reflexed, wings rather longer, keel still longer (about 2 in. (5 cm.) long) with a short indurated beak. Pod about 5½ in. (14 cm.) long, covered with close oblique pleats 3-5-seeded; seeds about 1 in. (2·5 cm.) across.

Mafulu.

Named after Mr. Evan R. Stanley, Government Geologist of Papua, who accompanied me on my two longer trips in the Territory. This new species comes very close to *M. Albertisii* F. Muell., but I think is sufficiently different to stand as a distinct species. The chief differences are as follow:—

M. Albertisii: Branchlets densely but rather closely ferruginous-pubescent; leaflets 3½-5 in (9-13 cm.) long; panicle branches velvety pubescent; calyx velvety pubescent with a few bristly hairs at the base of the tube ½-⅔ in. (1·3-1·7 cm.) long.

M. Stanleyi : Branchlets and panicle branches hirsute with long spreading hairs ; leaflets 4-6½ in. (10-16·5 cm.) long ; calyx hirsute with long brown hairs, 1 in. (2·5 cm.) long.

Canavalia obtusifolia DC. F. Muell. Pap. Pl., i (iii), 42 ; Bail. Rep. Visit B.N.G., 27, 28. Port Moresby.

Atylosia scarabæoides Benth. Sapphire Creek.

A. grandifolia F. v. M. Astrolabe Range. The Papuan specimens have a more robust appearance and are more densely pubescent than the Australian specimens but otherwise agree with them.

Rhynchosia Cunninghamii Benth. Yule Island.

Flemingia strobilifera R. Br. Bail. Queens. Agric. Journ., xxii, 147 ; xxiii, 220. Port Moresby ; Astrolabe Range.

F. lineata Roxb., var. **papuana** n. var. A stronger growing plant than the normal form ; branchlets densely ferruginous-pubescent ; leaflets up to 4¼ in. (10·7 cm.) long and 1¾ in. (4·5 cm.) broad ; panicles correspondingly large.

Sapphire Creek.

Dolichos Lablab Linn. F. Muell. Pap. Pl., i (v), 88. Astrolabe Range.

Family GERANIACEÆ.

Biophytum Apodiscias Turcz. Deva Deva (Mafulu District).

Family RUTACEÆ.

Evodia mollis Warb. Bella Vista (Mafulu District, 4,800 ft.).

[**E. alata** F. Muell. F. Muell. Pap. Pl., ii (vii), 26. Boku (Papua), *Mrs. H. P. Schlencker* ; near Finschhafen (late Kaiser Wilhelm's Land), *Dr. Carl Weinland* (No. 178) ; received from Botanic Gardens, Berlin, as **E. mollis** Warb.

Mrs. Schlencker's specimen represents a very robust form with leaflets nearly 1 ft. (31 cm.) long and 7 in. (18 cm.) broad and with the main veins very prominent beneath, and when flowers are available it may possibly prove a new variety or species.

E. mollis and *E. alata* are evidently closely allied, but can be distinguished by the following characters :—

E. mollis : Under surface of lamina of leaf closely covered by a dense velvety stellate tomentum.

E. alata : Veins and veinlets on the under surface covered (often thinly) by a stellate tomentum.]

E. lamprocarpa K. Sch. Javararie.

Lunasia quercifolia (Warb.) Laut. & Sch. Flora Deutschen Schutz. Sudsee, 376. *Androcephalium quercifolium* Warb. Pl. Hellwig. 197 (ex Engl. Jahrb. xviii 1893); *L. amara* F. Muell. Pap. Pl. (ii), viii, 42 (*non* Blanco). Sapphire Creek and Yule Island. Some of my Sapphire Creek specimens are in fruit. Cocci 4, often only 1 ripening, somewhat cuneate, 5 lines (1·1 cm.) long and about 4 lines (8 mm.) long at the top, valves tomentose, more or less prominently transversely wrinkled.

Flindersia papuana F. Muell., Pap. Pl., i (v), 84; C. T. White, Proc. Linn. Soc. N.S.W., 46. 329. Between Okaka and Mafulu.

Glycosmis pentaphylla Corr. F. Muell. Pap. Pl., i (iv), 54. Port Moresby: Bioto (Mekeo District).

Micromelium pubescens Bl. F. Muell. Pap. Pl., i (iv), 54; Bail. Rep. Visit B.N.G., 27: Queens. Agric., xxiv, 20. Sogeri District; Yule Island.

Murraya exotica Linn. Bioto (Mekeo District).

Family SIMARUBEÆ.

Harrisonia Brownii A. Juss. Port Moresby.

Family BURSERACEÆ.

Canarium australasicum F. Muell. Bail. Rep. Visit B.N.G., 27. Port Moresby.

Family MELIACEÆ.

Turræa pubescens Hellen. F. Muell. Pap. Pl., i (iv), 53. Port Moresby.

Melia Azedarach Linn. F. Muell. Pap. Pl., ii (vi), 5. White Cedar. Laloki River.

Chisocheton Biroi Harms. Branchlets myrmecophilous; flowers white; fruit red. Deva Deva.

It is with some hesitation I refer my specimens to the above and when better known it may prove a distinct species. It differs from typical *C. Biroi* in the leaves attaining over 60 cm. (2 ft.) in length and the individual leaflets over 20 cm. (8 in.) in length by 70 cm. (4 in.) in breadth. The branchlets also are myrmecophilous—a fact not mentioned by Harms. These, however, are all points that he might not have been able to see with the material at his disposal.

Aglaia elæagnoidea Benth. F. Muell. Pap Pl., i (i), 6. Yule Island.

A. sapindina (F.v.M.) Harms. Mekeo District.

Carapa moluccensis Lam. Bail Queens. Agric. Journ., ix, 410, and xxiv, 20. Port Moresby.

FAMILY EUPHORBIACEÆ.

Flueggea microcarpa Blume. Port Moresby.

The plant recorded as *Flueggea microcarpa* by Bailey in Queens. Agric. Journ. xxiii, 219, is a very different plant, probably an undescribed species of *Glochidion*.

Phyllanthus urinaria L. Mt. Warirata (Astrolabe Range).

Glochidion magnificum K. Sch. Mafulu.

My specimens are in fruit only, but I have little doubt of the determination. The capsules are densely pubescent, and about 4 lines (9 mm.) in diameter.

G. Ferdinandi Muell. Arg., var. **supra-axillaris** Benth. Mafulu.

Breynia cernua (Poir.) Muell. Arg. F. Muell. Pap. Pl., ii (6), 5. Mafulu.

Bridelia tomentosa Bl. Sapphire Creek.

A form with rather small leaves: it agrees fairly well with specimens from Somerset and Torres Strait, North Queensland (referred to by Bailey, Queens. Flora v, 141) and Rept. Aus. Assoc. Adv. Sc., vii, 442.

B. subnuda Schumm. & Laut. Bisiatabu.

In the absence of material for comparison, it is with some hesitation I make the above determination.

Claoxylon Hillii Benth. Sogeri.

Mallotus paniculatus Muell. Arg. Mafulu.

Macaranga angustifolia Laut. & K. Sch. Deva Deva.

M. punctata K. Sch. Bisiatabu (Astrolabe Range); also a doubtful specimen from the Mekeo District.

Acalypha insulana Muell. Arg. Astrolabe Range and Sogeri.

A. Hellwigii Warb., var. **mollis** Warb. Deva Deva and Mafulu.

For the determination of the above species of *Mallotus*, *Macaranga*, and *Acalypha* I am indebted to the Director, Royal Botanic Gardens, Kew, England.

* **Jatropha gossypiæfolia** Linn. Port Moresby. This South American plant is a great pest in parts of North Queensland.

Codiæum variegatum Bl., var. **moluccanum** Muell. Arg. (*C. chrysostictum* Rumph.). F. Muell. Pap. Pl., i (iv), 60. Yule Island.

Homalanthus populifolius Grah. Astrolabe Range and Sogeri.

Euphorbia Drummondii Boiss. Port Moresby. A small, red, decumbent weed ; the same form is common in coastal Queensland, and I have also received specimens from Fiji.

E. pilulifera Linn. Bail. Rep. Visit B.N.G., 27 ; Queens. Agric. Journ., xxiii, 220. Port Moresby (a common weed).

E. serrulata Reinw. Sapphire Creek and Astrolabe Range. A form with very narrow leaves with the edges almost entire.

* **E. (Poinsettia) heterophylla** Linn. Yule Island. A common weed in plantations, etc.

Family ANACARDIACEÆ.

Mangifera minor Bl. Port Moresby. A large handsome tree.

Buchanania papuana sp. nov.

Ramulis novellis dense pubescentibus, deinde glabris ; foliis glaberrimis, coreaceis lanceolatis oblanceolatis vel obovatis; a medio in petiolum cuneatim angustatis, nervis lateralibus circa. 10-15 patentibus ; paniculis pilosis deinde glabris ; calycis lobos triangularibus, petalis oblongis ; gynœcio strigoso ; drupis compressis ; breviter pilosis, apiculo excentrico.

A medium-sized tree with a spreading top. Young branchlets pubescent, older ones glabrous, lenticellate, stout. Leaves petiolate, petiole about 1 in. (2·5 cm.) long ; lamina 4½-7½ in. (11·5-19 cm.) long, 2-3 in. (5-7·5 cm.) broad ; lanceolate, oblanceolate or sometimes obovoid, glabrous, main lateral nerves prominent on both faces. Panicle about as long as the leaves, widely spreading, rhachis and branchlets bearing a few scattered hairs but soon quite glabrous. Calyx about ½ line (1 mm.) long, glabrous or almost so, lobes triangular. Petals about 1 line (2 mm.) long, oblong. Anthers sagittate. Gynœcium strigose-pubescent. Drupe with a few scattered hairs, 3-4 lines (6-9 mm.) in diameter, compressed-globose ; apex almost terminal.

Laloki River.

This new species is very closely allied to the common Australian *B. Muelleri*, from which it is distinguished chiefly by its larger more

coriaceous and more strongly veined leaves, its wider spreading panicle, and more pointed calyx lobes. In systematic position it comes between *B. florida* and *B. Muelleri.*

B. florida: Drupe glabrous, apex excentric. Leaves 10-15 cm. long, 4-5 cm. broad.

B. Muelleri: Drupe clothed with a few scattered hairs. Leaves ca. 10 cm. long, 5-6 cm. broad.

B. papuana: Drupe clothed with a few scattered hairs. Leaves 11-19 cm. long, 5-7·5 cm. broad.

Semecarpus australiensis Engler. Port Moresby.

S. undulata sp. nov.

Arbor humilis, ramulis crassis; foliis breviter petiolatis obovato-lanceolatis breviter acuminatis, basim versus a triente superiore longe cuneatim angustatis, undulatis, coriaceis, supra glabris nitidulis, subtus pallidis reticulatis, costa et nervis lateralibus tenuiter pilosis, venis tenuiter pilosis et glanduloso-punctatis; paniculis axillaribus vel lateralibus, elongatis, ramulis tenuis glabrescentibus: floribus masculis glomeratis, calycis 5-lobis, strigoso-pubescentibus, petalis strigoso-pubescentibus, staminibus glabris petalis æquantibus: drupis ovoideis compressis pubescentibus, apiculo centrico hypocarpio obconicó, pubescentibus.

A small tree, usually with a single stem, the leaves arranged around it in dense false whorls. Leaves subsessile, or very shortly petiolate on a petiole of 2-5 lines (·4-1·1 cm.): lamina 7-14 cm. (17·5-36 cm.) long; obovate-lanceolate. Apex shortly and rather bluntly acuminate, lower part gradually tapering to the base, under surface pale coloured—but not white—with a very dense close tomentum between the veinlets, the veins and veinlets prominently raised, clothed with a few scattered hairs and glandlike markings. Panicles lateral or axillary, branched at the base into several elongate slender branches, the branches glabrescent, the main rhachis in the specimens to hand attaining 2 ft. 9 in. (82·5 cm.) long. Male flowers whitish, in dense clusters along the branches of the panicle; calyx strigose-pubescent, 5-lobed, scarcely ½ line (1 mm.) long; petals strigose-pubescent on the outer surface; scarcely 1 line (1½ mm.) long, stamens about the same length as the petals, filaments glabrous, slightly flattened at the base. Female flowers unknown. Drupe green (perhaps not seen quite ripe), about 1¼ in. (3·2 cm.) long and ¾ in. (2 cm.) broad in the dried specimens, compressed-ovoid, apex almost centric; pericarp

pubescent with a close ferruginous pubescence, easily rubbed off in the dried fruit; receptacle densely ferruginous-pubescent with a close pubescence about 5 lines (1·1 cm.) in diameter.

Astrolabe Range (type); Port Moresby.

The Astrolabe Range specimens bear both flowers and fruits. The Port Moresby specimens have leaves rather longer and narrower and more markedly sessile than the Astrolabe ones; the panicle is also somewhat differently branched. But I have little hesitation in referring it to the same species.

Semecarpus sp. Leaves shortly petiolate, petiole about 1½ in. (4 cm.) long; lamina up to 15 in. (37·5 cm.) long and 5½ in. (13·7 cm.) wide, glaucous beneath. Drupe (not seen quite ripe) obliquely obcordate, about 1 in. (2·5 cm.) across; compressed, thinly pubescent; receptacle obconical, about ¼ in. (·6 mm.) long, pubescent.

Javararie.

Probably represents a new species but the material hardly allows me to name it. In addition to the above I collected a species in flower only at Yule Island: and in the Queensland Herbarium there is another apparently undescribed species from Boku, collected by Mrs. H. P. Schlencker; the material consists of one leaf and a couple of ovoid, fulvous-pubescent fruits.

FAMILY SAPINDACEÆ.

Cardiospermum Halicacabum Linn. F. Muell. Pap. Pl., i (iv). 53; Bail. Rep. Visit B.N.G., 27. Port Moresby.

Alectryon ferrugineum (Bl.) Radlk. *Nephelium ferrugineum* Bl.; F. Muell. Pap. Pl., i (ii), 21. Port Moresby.

Mischocarpus lachnocarpus (F. Muell.) Radlk. *Ratonia lachnocarpa* F. Muell. Mekeo District.

Jagera serrata (Roxb.) Radlk. Sogeri.

Dodonæa viscosa Linn. F. Muell. Pap. Pl., i (ii), 21. Mafulu, 4,000 ft.

FAMILY BALSAMINACEÆ.

Impatiens sp. Mafulu—very abundant along mountain roadside (3,000-4,000 ft.). My specimens are rather too imperfect to determine specifically.

FAMILY RHAMNACEÆ.

Colubrina asiatica Rich. F. Muell. Pap. Pl., i (i), 7. Port Moresby.

Gouania microcarpa P. DC. Astrolabe Range.

FAMILY VITACEÆ.

Cissus trifolia (Linn.) K. Sch. *Vitis trifolia* Linn.; F. Muell. Pap. Pl., i (v), 86. Port Moresby.

C. pedata Lam. *Vitis pedata* Wall. Astrolabe Range.

[**C. discolor** Lam. *Vitis cordata* Bail. Queens. Agric. Journ., iii, 154, 1898 (*non* Wall.) Mambare River, *F. M. Bailey*.

I have little hesitation in referring Bailey's plant to *C. discolor*. The leaf in the dried specimens shows no white marking, but these are not always present. Bailey l.c. describes the inflorescence as red, a character of some forms of *C. discolor*.]

Leea sambucina Willd. Bail. Rep. Visit B.N.G., 27, 28. Port Moresby; Astrolabe Range. It is recorded for Darnley Island by Mueller in his "Papuan Plants," i (iii), 36, but this is in Queensland territory.

L. æquata Linn. Sogeri.

FAMILY TILIACEÆ.

Grewia orientalis Linn. F. Muell. Pap. Pl., ii (viii), 41. Port Moresby; Yule Island.

G. latifolia F. Muell. Port Moresby.

Triumfetta rhomboidea Jacq. F. Muell. Pap. Pl., ii (ix), 56; Bail. Rep. Visit B.N.G., 27. Port Moresby; Yule Island.

T. pilosa Roth. F. Muell. Pap. Pl., ii (ix), 56. Javararie; Mafulu.

T. semitriloba Linn. Bail. Queens. Agric. Journ., xxiii, 220.

Althoffia pleiostigma (F. Muell.) Warb. (*Grewia pleiostigma* F. Muell.); F. Muell. Pap. Pl., i (iv), 58. Sapphire Creek. A very pretty tree with lavender-coloured flowers.

A. tetrapyxis K. Sch. Astrolabe Range; Mafulu.

I very much doubt if these two species of *Althoffia* can be kept distinct. My specimens of the former are in flower, of the latter in fruit. We also have fruiting specimens of *A. tetrapyxis* from Mrs. Schlencker, collected at Boku, with the remark, "Bears small white flowers"; so I have refrained from uniting them until more definite information is to hand.

FAMILY MALVACEÆ.

Abutilon auritum G. Don. F. Muell. Pap. Pl., i (iv), 55. Port Moresby. Very common in the native gardens.

A. asiaticum G. Don. Port Moresby.

Sida spinosa Linn. F. Muell. Pap. Pl., i (iv), 55. Port Moresby.

S. acuta Burm. Yule Island.

S. rhombifolia Linn. *S. retusa* L. Port Moresby.

S. cordifolia Linn. Flannel weed. Port Moresby.

***Malvastrum tricuspidatum** A Gray. Port Moresby.

Urena lobata Linn. F. Muell. Pap. Pl., i (iv), 55 ; Becc. in D'Albertis' "New Guinea," ii, 396 ; Hemsl. Kew Bulletin 1899, 97. Sapphire Creek ; Astrolabe ; Sogeri ; Mafulu.

The species of *Sida, Malvastrum, and Urena* here recorded are common Asiatic, Papuan, and Tropical Australian weeds.

Hibiscus ficulneus Linn. F. Muell. Pap. Pl., i (iv), 56. Port Moresby. As in parts of Northern Queensland during the winter months, the upright dead stems with their racemes of old capsules can be seen everywhere in the grass land.

H. D'Albertisii F. Muell. Pap. Pl., i (iv) 55 and ii (viii), 41. Very common between Kubunah and Fofofofo (Mekeo District).

H. vitifolius Linn. F. Muell. Pap. Pl., i (iv), 56. Bioto (Mekeo District).

H. tiliaceus Linn. F. Muell. Pap. Pl., i (iv), 56 ; Bail. Rep. Visit B.N.G., 27. Port Moresby.

FAMILY BOMBACACEÆ.

Bombax malabaricum DC. ; Bail. Rep. Visit B.N.G., 27. Silk Cotton tree. Port Moresby ; Yule Island. This tree, bearing its large red flowers, is a conspicuous feature in the landscape.

FAMILY STERCULIACEÆ.

Melochia pyramidata Linn. F. Muell. Pap. Pl., i (iii), 36. Port Moresby.

M. vitiensis A. Gray. F. Muell. Pap. Pl., i (iv), 55. Sapphire Creek ; Astrolabe Range ; Sogeri.

[**M. indica** (Houtt) A Gray. *Commersonia* sp. F. M. Bail. in Ann. Rept. B.N.G. 1900-01, p. 142. East Coast, British New Guinea, *Sir G. R. Le Hunte*.]

Waltheria americana Linn. Port Moresby. A common weed.

Abroma augusta Linn. f. F. Muell. Pap. Pl., i (iii), 36; *A. fastuosa* Bail. Queens. Agric. Journ., xxiv, 20 (*non* R. Br.). Port Moresby.

Can be distinguished from the common Australian *A. fastuosa* R. Br. by its entirely unarmed branches and branchlets.

Sterculia Edelfeldtii F. Muell. Vic. Nat., iii, 47; Pap. Pl., ii (ix), 55. Yule Island; Kubunah (Mekeo District).

The Yule Island specimens are in flower, the Kubunah specimens in fruit, and seem to represent two forms both of which I doubtfully refer to *S. Edelfeldtii*, which is evidently either a very variable plant or else more than one species was included by Mueller l.c. under it.

FAMILY DILLENIACEÆ.

Wormia sp. Dilava. My specimens consist of a couple of leaves and a few fallen flowers only, and do not allow me to give a specific name. It is a large tree producing a useful timber known at Dilava as "Manava." The leaves are borne on a petiole of about 2½ in. (6·3 cm.), lamina suborbicular about 7 in. (17·5 cm.) long and 6½ in. (16·5 cm.) broad, strongly veined on the under surface.

FAMILY BIXACEÆ.

Cochlospermum Gillivræi Benth. F. Muell. Pap. Pl., i (iv), 54; Bail. Queens. Agric. Journ., xxiv, 20. Port Moresby. A small tree very common on rocky foreshores round the harbour.

Bixa Orellana Linn. Bail. Queens. Agric. Journ., vii, 348, and xxiii, 221. Sogeri; Mafulu.

FAMILY PASSIFLORACEÆ.

Passiflora fœtida L. Naturalised almost everywhere near settlements.

FAMILY SONNERATIACEÆ.

Sonneratia alba Sm. Bail. Ann. Rep. B.N.G. 1900-01, p. 143. Port Moresby.

S. lanceolata Bl. A riverside or estuarine tree, sending up numerous slender pneumatophores; branchlets slender, glabrous. Leaves glabrous, lanceolate or ovate-lanceolate, oblique and tapering at the base into a short petiole; petiole about 3 lines (6 mm.) long; lamina 3-4 in. (7·5-10 cm.) long and ¾-1 in. (2-2·5 cm.) broad. Flowers apetalous. Calyx 6-lobed, stamens white, numerous. Fruit about 1 in. (2·5 cm.) across.

Ethel River (very abundant).

I have little doubt in referring my specimens to *S. lanceolata* Bl. (Mus. Lugd. Bot., i, 337). He describes the flower as 6-petaled: the only flower available to me is apetalous, but this is not sufficient ground for separation. The only description of the plant I have at my command is Blume's original one. In the field at a cursory glance the tree might easily be mistaken for the widely distributed *Avicennia officinalis*; it is very different in appearance from the much commoner congener *S. alba*.

FAMILY LECYTHIDACEÆ.

Barringtonia calyptrata O. Ktze. C. T. White, Proc. Linn. Soc. N.S.W., xliv, 823. Yule Island.

FAMILY RHIZOPHORACEÆ.

Rhizophora mucronata Lam. Red Mangrove. Port Moresby. The principal tanning mangrove.

Ceriops Candolleana Arn. Small Mangrove. Port Moresby.

Bruguiera gymnorhiza Lam. (*B. Rheedii* Bl., F. Muell. Pap. Pl., viii, 44.) Port Moresby. Hooker (Flora British India, ii, p. 437) unites *B. Rheedii* with *B. gymnorhiza*.

B. eriopetala W. & A. Port Moresby.

FAMILY COMBRETACEÆ.

Terminalia Catappa Linn. Fiji Almond. Bail. Rep. Visit B.N.G., 27: Foxworthy Ann. Rep. Papua 1909-10, p. 114. Yule Island.

Planted in the streets of Port Moresby as a shade tree.

T. Okari sp. nov.

Arbor magnis; ramulis novellis ferruginoso-pubescentibus; foliis breviter petiolatis obovatis (20-27·5 cm. longis, 10-12·5 cm. latis), supra glabrescentibus subtus prominente nervosis, nervis dense pubescentibus; floribus ignotis; drupis obovoideis, magnis (ca. 17·5 cm. longis et 7·5 cm. latis); pericarpio fibroso, endocarpio osseo, semine ellipsoideo (ca. 7·5 cm. longo et 2 cm. lato).

A tall tree, young shoots densely ferruginous-pubescent. Leaves obovate, tapering at the base into a short petiole, 8-11 in. (20-27·5 cm.) long, 4-5 in. (10-12·5 cm.) wide, glabrous above with the exception of a few scattered hairs on the midrib and main lateral nerves; under surface prominently veined,

the midrib and main lateral nerves raised and densely ferruginous-pubescent; petiole pubescent about 1 in. (2·5 cm.). Flowers not seen. Fruit deep reddish purple, obovoid, about 7 in. (17·5 cm.) long and 3 in. (7·5 cm.) broad; pericarp fibrous with interlacing fibres, endocarp ossified, very rugose; seed narrowly ellipsoid, about 3 in. (7·5 cm.) long and ¾ in. (2 cm.) broad; testa thin, dark brown.

Bisiatabu (type); Sogeri (common); [Boku, *Mrs. H. P. Schlencker*].

A large tree; the seed, known in Papua as the "Okari nut," is a favourite with natives and Europeans alike; by the latter the nuts are often eaten "devilled" in the same way as almonds. It is probably one of the finest of tropical nuts.

Combretum Goldieanum F. Muell. Pap. Pl., i (iv), 66. Port Moresby; Yule Island.

This rambling scandent shrub is very common about Port Moresby and with its brilliant red flowers is quite a conspicuous feature in the vegetation. The fruits are "shortly stipitate, nearly 1 in. (2·5 cm.) long, and prominently winged with 5 dry more or less membranous wings."

Gyrocarpus americanus Jacq. F. Muell. Pap. Pl., ii (vi), 7; Vic. Nat. Feb. 1885. Port Moresby.

FAMILY MYRTACEÆ.

Rhodamnia cinerea Jack. Bisiatabu.

The specimens are in leaf only but I have little hesitation in referring them to the above species. I cannot follow King ("Materials for a Flora of the Malayan Peninsula") and others in uniting so many species under *R. trinervia.*

Decaspermum neurophyllum Laut. & K. Sch. Deva Deva. A large shrub or small tree; flower-buds pink; in the open flower the petals white or flesh-coloured and stamens pink.

Melaleuca sp. (aff. *M. Leucadendron* Linn.). Astrolabe Range.

This tree is common on the range. It has a papery bark and white flowers. For the present I do not care to give it a specific name. I cannot class all the various forms allied to *M. leucadendron* L. as varieties, as done by King ("Materials for a Flora of the Malayan Peninsula"), Cheel (in Ewart & Davies's "Flora of the Northern Territory"), and others.

* **Eucalyptus tereticornis** Sm. Blue Gum of Queensland, Forest Red Gum of N. S. Wales. F. Muell. Pap. Pl., ii (ix), 59;

* For the identification of the Eucalypts I am indebted to Mr. J. H. Maiden, I.S.O., F.R.S., Govt. Botanist, Sydney.

Ann. Rep. B.N.G. 1889-90, 106; Maid. Proc. Linn. Soc. N.S.W. xxvi, 540; Forest Flora N.S.W. ii, 3; Critical Rev. Gen. Euc. iv, 11. Astrolabe Range (common).

E. alba Reinw. Poplar Box, White Box of North Queensland. Maiden, Critical Revision Gen. Euc., iii, 97; *E. platyphylla* F. Muell.; Bail. Rep. Visit B.N.G., 27. Port Moresby (the common broad-leaved form); Astrolabe Range (leaves much narrower, even to narrow lanceolate). This tree is readily distinguished in the field by its clean white trunk and branches.

E. clavigera A. Cunn. Port Moresby; Astrolabe Range. This Eucalypt is fairly common, and easily distinguished by the blackish tessellated bark at the butt, extending for about 5 to 10 ft. up the trunk.

E. papuana F. Muell. Pap. Pl., i (i), 8; Bail. Rep. Visit B.N.G., 27; Maid. Crit. Rev. Gen. Euc., iv. 196. Port Moresby (very common).

Family MELASTOMACEÆ.

Otanthera bracteata Korth. Mafulu.

O. setulosa K. Sch. Nacht. Fl. Deutsch. Schutzg. Sudsee. 327. Sogeri. The fruits are red and about 8 lines (1·7 cm.) diameter.

Melastoma polyanthum Bl. Astrolabe Range, and range between Sogeri and Javararie.

Osbeckia chinensis Linn. Mt. Warirata (Astrolabe Range).

Medinilla Forbesii E. G. Baker in Trans. Linn. Soc., n. ser., Bot., ix, 55. Dilava.

Family ŒNOTHERACEÆ.

Jussiæa suffruticosa Linn. F. Muell. Pap. Pl., i (iv), 60; Bail. Rep. Visit B.N.G., 28. Port Moresby.

Family HALORRHAGIDACEÆ.

Gunnera macrophylla Bl., var. **papuana** Warb. Deva Deva.

Family UMBELLIFERÆ.

Hydrocotyle hirta R. Br. Javararie. A common weed on damp plantation tracks.

Family MYRSINACEÆ.

Ægiceras majus Gærtn.; Bail. Ann. Rep. B.N.G. 1900-01, p. 143; *A. fragrans* Koenig, F. Muell. Pap. Pl., i (iv), 70. Port Moresby. A common tree in the mangrove swamps.

Family PLUMBAGINACEÆ.

Plumbago zeylanica Linn. F. Muell. Pap. Pl., i (iv), 58. Port Moresby.

Family SAPOTACEÆ.

Mimusops parvifolia R. Br. Port Moresby; Yule Island.

Family EBENACEÆ.

Diospyros maritima Bl. Yule Island and mainland opposite (Mekeo District).

Family OLEACEÆ.

Jasminum didymum Forst. F. Muell. Pap. Pl., i (i), 11. Port Moresby.

Family LOGANIACEÆ.

Fagræa obovata Wall., var. **papuana** Bail. Queens. Agric. Journ. iii, 157 (1898). Sapphire Creek and Astrolabe Range.

Family APOCYNACEÆ.

Alstonia scholaris R. Br. F. Muell. Pap. Pl., i (iv), 70; Hemsley Kew Bull. 1899, 106; Foxworthy in Ann. Rep. Papua 1909-10, p. 114. Port Moresby. A very common tree. In North Queensland known as "Milky Pine."

A. longissima F. Muell. Pap. Pl., i (v), 91. Port Moresby.

Family ASCLEPIADACEÆ.

Dischidia Rafflesiana Wall. Bisiatabu (Astrolabe Range). Epiphytic on trees.

[**D. ovata** Benth. Kwato Island, *E. Cowley*.]

Family CONVOLVULACEÆ.

Ipomæa grandiflora Lam. Port Moresby. A climber with large white flowers.

I. Turpethum R. Br. F. Muell. Pap. Pl., ii (viii), 49. Yule Island.

Lepistemon urceolatus F. v. M. Mafulu.

Convolvulus multivalvis R. Br. Port Moresby.

Merremia bufalina (Lour.) Merr. & Rolfe. Port Moresby.

FAMILY BORAGINACEÆ.

Cordia subcordata Lam. F. Muell. Pap. Pl., i (iii), 44; Bail. Rep. Visit B.N.G., 27, 28; Queens. Agric. Journ., ix. 411 (1901). Port Moresby. The Rev. H. P. Schlencker gave me the native name about Port Moresby for this plant as "Turi-turi."

Tournefortia mollis F. Muell. F. Muell. Pap. Pl., i (iv), 71. Port Moresby. Common on the hills.

T. sarmentosa Linn. f. F. Muell. Pap. Pl., i (i), 11. Mekeo District.

FAMILY VERBENACEÆ.

Geunsia farinosa Blume. Mafulu.

Callicarpa longifolia Lam. Hemsley Kew Bull. 1899, 108.

C. caudata Maxim. Mafulu. I have not got the original description of this species to refer to but have named it by comparison with Philippine material of typical *C. caudata* received from Dr. E. D. Merrill, Bureau of Science, Manila. P.I.

[**C. pedunculata** R. Br. Boku, *Mrs. H. P. Schlencker*. Papuan name "Manutagi."]

Premna obtusifolia R. Br. Bail. Queens. Agric. Journ., xxiii. p. 220. Port Moresby.

P. nitida K. Sch. Astrolabe Range.

Vitex trifolia Linn. F. Muell. Pap. Pl., i (i), 11; Bail. Rep. Visit B.N.G., 27. Port Moresby; [Samarai, *W. E. Armit*].

Clerodendron inerme R. Br. F. Muell. Pap. Pl., i (i), 11. Port Moresby; [Normanby Island, *Sir. G. R. Le Hunte*]; [Port Moresby, *E. Cowley*, who quotes the native name as "Quamo-quamo."]

C. floribundum R. Br. F. Muell. Pap. Pl., i (v), 90; Bail. Queens. Agric. Journ., xxii, 148. Port Moresby.

C. Tracyanum F. Muell. F. Muell. Pap. Pl., i (v), 91; Bail. Ann. Rep. B.N.G. 1900-01, p. 143. Mekeo District [Samarai, *W. E. Armit*].

Avicennia officinalis Linn. Bail. Rep. Visit B.N.G., 28, and in Ann. Rep. B.N.G. 1900-01, 143. Port Moresby.

Family LABIATÆ.

Anisomeles salvifolia R. Br. Port Moresby. A very robust form common on the hills about the town. Mueller (Pap. Pl., i (iii), 45) records this from Darnley Island, which is, however, in Queensland territory.

***Hyptis sauveolens** Poit. C. T. White, Queens. Agric. Journ., xii, n.s. 141, pl. 16 (1919). Port Moresby. A very common weed.

Coleus scutellarioides Benth. F. Muell. Pap. Pl., ii (vi), 15. Sogeri.

Ocimum basilicum Linn. *O. sanctum* Bail. Ann. Rep. B.N.G. 1900-01, 143 (*non* Linn.). Port Moresby; [Cape Nelson, *G. R. Le Hunte*]. A strongly scented herb; a common weed in native gardens, etc.; worn by men in armlets, especially at native dances.

O. sanctum Linn. F. Muell. Pap. Pl., i (v), 90; Bail. Rep. Visit B.N.G., 27, 28; (*Moschosma polystachyum* Bail. in Queens. Agric. Journ., xxiii, 148, and xxiv, 120 *non*. Benth). Yule Island; [Port Moresby, *E. Cowley*; Boku, *Mrs. H. P. Schlencker*].

Orthosiphon stamineus Benth. F. Muell. Pap. Pl., i (iii), 45; Bail. Rep. Visit B.N.G., 27, 28. Sogeri.

Family SOLANACEÆ.

Solanum viride R. Br. F. Muell. Pap. Pl., ii (viii), 49. Sogeri.

S. verbascifolium Ait. F. Muell. Pap. Pl., i (iii), 44; Bail. Queens. Agric. Journ., xxiii, 220. Port Moresby.

[**S. torvum** Sw. Hemsley Kew Bull. 1899, 107; *S. stelligerum* Bail. in Ann. Rep. B.N.G. 1900-01, 143 (*non*. Sm.). Trobriand Islands, *G. R. Le Hunte*.

These specimens, referred by Bailey l.c. to *S. stelligerum*, represent to my mind typical *S. torvum*.]

S. torvum Sw. Sogeri. A common *Solanum* in secondary growth, height about 10 ft., flowers white, berries about 4 lines (9 mm.) in diameter, but only seen green.

This possibly represents a new species; it approximates closely a densely tomentose form growing in the Philippines. I wrote Mr. Merrill, Director, Bureau of Science, Manila, P.I., about these Papuan specimens, and he replied: "I note your query in reference to *S. torvum*. The specimens certainly very strongly resemble Philippine material which I have referred to this species for want of a better disposition of such material. We have typical *S. torvum* in the Philippines growing in waste places and about towns. It is erect, branched, suffrutescent,

spiny, and has white or nearly white flowers. The Philippine form which approximates your New Guinea specimen has purple or violet flowers, and I am by no means certain whether it can be referred to *S. torvum*."

S. repandum Forst. F. Muell. Pap. Pl., i (v), 91. Sogeri.

S. discolor R. Br. Bioto (Mekeo District).

FAMILY SCROPHULARIACEÆ.

Limnophila gratioloides R. Br. F. Muell. Pap. Pl., ii (ix), 63; Ann. Rep. B.N.G. 1889-90, 107.

Vandellia crustacea Benth. F. Muell. Pap. Pl., i (v), 99; Bail. Queens. Agric. Journ., xxii, 148: Hemsley in Kew Bull. 1899, 107. Sogeri.

Bonnaya veronicæfolia Spreng. Laloki River; Mekeo District.

Buchnera urticifolia R. Br. Mt. Warirata.

FAMILY BIGNONIACEÆ.

Diplanthera tetraphylla R. Br. Astrolabe Range and Sogeri. A very common tree.

FAMILY GESNERIACEÆ.

Bœa lanuginosa Sch. & Laut. Bisiatabu (on rocks). My specimens are rather fragmentary but belong, I believe, to the above.

Rhyncoglossum obliquum Bl. Deva Deva. A pretty blue-flowered herb common along forest tracks in the Mafulu District.

FAMILY ACANTHACEÆ.

An account of the Acanthaceæ collected will be found in a paper "Acanthaceæ Papuanæ" by Mr. Spencer Le M. Moore, B.Sc., F.L.S., in the "Journal of Botany," vol. 58, pp. 190-195 (1920).

FAMILY RUBIACEÆ.

(By Spencer Le M. Moore, B.Sc., F.L.S., Dept. of Botany, British Museum of Natural History, London.)

Nauclea Chalmersii F. Muell. Pap. Pl., ii (viii), 44. Bisiatabu (357).

[**Uncaria pedicellata** Roxb. Boku, *Mrs. H. P. Schlencker*.]

[**U. appendiculata** Benth. B. N. Guinea (without precise locality), *W. E. Amit*.]

U. appendiculata Benth. Forma foliis pag. sup. fere glabris. Sogeri; and between Sogeri and Javararie.

[**U. Schlenckeræ** S. Moore, sp. nov.

Frutex scandens, pubescens; *ramis* sat validis optime tetragonis fulvo-pubescentibus; *foliis* brevipetiolatis ovatis basi rotundatis margine integris vel dentato-undulatis rigide membranaceis pag. sup. sparsim pag. inf. (in axillis costarum perspicue barbatis) dense fulvo-pubescentibus costis lateralibus utrinque circa 7 pag. inf. eminentibus; *stipulis* quam petioli longioribus ambitu late rotundatis medium usque bilobis pubescentibus lobis triangularibus obtusis; *pedunculo sterili* unico viso petiolis circa ter longiore pubescente; *pedunculis fertilibus* petiolis multo longioribus inferne incrassatis pubescentibus; *capitulis* multifloris; *floribus* pedicellatis uti ovarium calyxque dilute fulvo-tomentosis; *ovario* anguste ovoideo quam calycis pars libera indivisa longiore; *calycis* parte indivisa brevi cylindrica hujus lobis 5 (casu 6) linearibus obtusis vel anguste lineari-spathulatis quam pars indivisa longioribus extus pubescentibus; *corollæ* tubo subcylindrico ex calyce longe eminente extus pubescente lobis oblongo-obovatis obtusis tube multe brevioribus; *antheris* breviter exsertis, *stylo* longe exserto glabro stigmate anguste claviformi coronata; *capsula* anguste obovoideo-oblonga longitrorsum costata puberula.

Boku, *Mrs. H. P. Schlencker.*

Rami 3-4 mm. crass. Folia (perfecta haud obvia) circa 9-11 × 6·5-8·5 cm., in sicco pag. sup. atro-castanea, pag. inf. viridi-brunnea; petioli 5 mm. long. Stipulæ 1 cm. long. Pedunculus sterilis 1·5 cm., pedunculi fertiles 3-3·5 cm. long. Capitula 3 cm. diam. Pedicelli subflore 5-6 mm. sub fructu usque 9 mm. long. Ovarium 3 mm., calycis pars libera indivisa 1·25 mm., hujus lobi 2·25-2·5 mm. long. Corollæ tubus 8 mm. long., inferne ·5 mm, sub limbo usque 1 mm. gradatim ampliatus; lobi 2-3 mm. long. Antheræ 1·6 mm. long. Stylus 12 mm., stigma 2·5 mm. long.

Affinity with *U. velutina* Havil., which *inter alia* has quite different leaves and longer and narrower capsules.]

Uncaria sp. Deva Deva. Not identified, and may prove to be a new species characterised by the short pedicels (often united at bottom) and short young fruit, shorter indeed than the setaceous lobes of the calyx. The specimen is too incomplete for closer determination.

Wendlandia buddleacea F. Muell. Pap Pl. ii. (viii) 45. Astrolabe Range (296).

Hedyotis Auricularia Linn. Sogeri.

Hedyotis sp. On range between Sogeri and Javararie. Apparently a new species close to *H. pinifolia* Wall., distinguished from it chiefly by the very short corollatube, i.e. much shorter than the calyx (instead of longer than it as in *H. pinifolia*) and the small capsule.

Mussænda Whitei S. Moore, sp. nov.

Frutex; ramulis sat validis breviter ferrugineo-tomentosis; *foliis* ovatis breviter acuminatis apice acutis basi in petiolum aliquanto angustatis membranaceis supra subsparsim subtus dense pubescentibus costis lateralibus utrinque 10 uti costulæ inter costas more *Brideliarum* fere rectæ pag. inf. eminentibus pag. sup. parum perspicuis; stipulis triangularibus bifidis facie utravis pubescentibus; *cymis* terminalibus foliis circiter æquilongis e cymulis pluribus laxe ordinatis compositis ferrugineo-tomentosis; *floribus* pro cymula pluribus breviter pedicellatis; *bracteis* subulato-setaceis pubescentibus; *ovario* cylindrico uti calycis segmenta lineari-setacea sordide albo-tomentoso; *calycis* segmento foliaceo dum adsit ovata obtuso stipite brevi insidente utrinque pubescente albo; *corollæ* parvæ tubo ultra medium gradatim sed leviter ampliato extus pilis fulvis appressis dense vestito lobis ovato vel oblongo-lanceolatis acutis pubescentibus; *fructu* ———.

Mafulu (502).

Folia plerumque 7-10 × 4-6 cm.; petioli 2-3 cm., stipulæ 7·5 mm. long. Cymæ usque circa 10 × 8 cm. Bracteæ ± 8 mm. long. Pedicelli circa 2 mm. long. Ovarium 4 mm., calycis segmenta 5-6 mm. long.; hujus segmentum foliaceum 5 × 4 cm. stipite 7 mm. long. excluso. Corolla ex schedis cl. detectoris flava; tubus 21 mm. long., inferne 1 mm. sublimbo 3 mm. lat.; lobi 5 mm. long.

A very distinct species with its small corollas and short-stalked foliaceous calyx-segments among other features.

M. procera Bail.? Bail. Queens. Agric. Journ., iii, 155 (1898). Astrolabe Range; [Boku, *Mrs. H. P. Schlencker.*] No specimen of this either at the British Museum or at Kew. Not identified among New Guinea species in those collections.

M. frondosa Linn., var. **pilosissima** Engl. Sapphire Creek, Sent under the above name by Mr. White, but some doubt must attach to the determination; I have seen no authentic dsecimen of this variety.

[**Mussænda** sp nov. ? Village of Tina, St Joseph River; Coll. ignot. Not identified: expanded corollas required for precise naming.]

Tarenna sp. Mekeo District (789). Specimen incomplete.

Gardenia ? sp. nov. Fofofofo. Quite unlike any Papuan species hitherto described. In absence of flowers, not desirable to describe. Seeds not immersed in pulp a peculiarity. (Almost certainly a *Gardenia*.)

Guettarda speciosa Linn. Port Moresby.

Timonius Rumphii DC. Port Moresby, and common on Astrolabe Range and Yule Island (17, 737). (Det. H. F. Wernham, D.Sc.)

T. cryptophlebus S. Moore, sp. nov.

Arbuscula, ramulis compressis subdistanter foliosis ferrugineo-tomentosis deinde glabrescentibus; *foliis* brevi-petiolatis oblongo-oblanceolatis obtusis basi breviter cuneatis chartaceis pag. sup. minute puberulis sublenteque striatulis sæpe confluentibus plus minus aspectabilibus copiose præditis pag. inf. præsertim in costa media hirsutulo-pubescentibus costis lateralibus uti reticulum pag. utriusque omnino vel fere omnino invisibilibus; *stipulis* ———— ; *floribus* pedicellis brevibus compressis ferrugineis insidentibus; *ovario* quam calyx breviter cupularis glaber longiore cylindrico paucisulcato fere glabro ∞-loculari; *corollæ* 5-meræ tubo late cylindrico extus sordide albo-tomentoso lobis crassiusculis tubo brevioribus ovato-lanceolatis apice integris bifidisve vel etiam bipartitis; *antheris* 5 inclusis prope medium tubum insertis; *stylo* robusto glabro striis obviis percurso ramis 6 onustis.

Dilava (No. 428).

Folia in sicco brunnea, pleraque 7-10 × 3-4 cm., summa vero minora; petioli 1-1·5 cm. long., ferruginei. Pedicelli verisimiliter 5 mm. long. Ovarium 2-3 × 4 mm. Calyx 1-·15 mm. long. Corolla alba, humectata in toto 11 mm. long.; lobi soli 4 mm.; tubus 3 mm. lat. Antheræ sessiles, 3 mm. long. Stylus 4·5 mm., hujus rami 4 mm. long. Drupa (fortasse vix matura) eximie sulcata, fusca, 7 mm. diam.

The specimen is not wholly satisfactory, the few flowers and fruits being unattached, and stipules absent. Nevertheless without doubt it differs in several points from all described Papuan species. The striation of the leaves' upperside is a good deal like that of *T. avenis* Valet., as figured in Nova Guinea viii, t. lxxii.

Knoxia corymbosa Willd. F. Muell. Pap. Pl. i. (iii) 43. Sapphire Creek.

Ixora Whitei S. Moore, sp. nov.

Arbuscula ? glabra; *ramulis* ultimis aliquante compressis distanter foliosis; *foliis* brevipetiolatis oblongo-lanceolatis superne gradatim longiuscule acuminatis apice obtusis basi subrotundatis pergamaceis pallide nitidis glandulis translucentibus permultis microscopicis præditis costis lateralibus utrinque 18-22 angulis variis costæ centrali insertis pag. sup. vix pag. inf. (uti reticulum valde laxum) sat aspectabilibus; *stipulis* parvis inferne ovatis in acumen brevem subito exeuntibus: *panicula* terminali foliis circiter æquilonga angusta pedunculo elongato compresso insidente e cymulis paucis breviter pedunculatis paucifloris sistente hujus *ramis primariis* suboppositis ultimis alternis uti pedicelli abbreviati validi minute puberulis; *bracteis* parvulis subulatis *ovario* pyriformi quam calyx cyathiformis minutissime 4-denticulatis longiore; *alabastris* obtusis; *corollæ* tubo angusto intus in faucibus glabro lobis 4 oblongis obtusis tubo æquilongis; *antheris* subsessilibus acuminatis; *stylo* pilosiusculo ramis linearibus onusto.

Mekeo District (798).

Folia 21-25 × 6·5-8·5 cm., in sicco grisea; petioli validi, levissime torti, late canaliculati, 8-12 mm. long. Stipulæ pars lata 4 mm., acumen vix 2 mm. long. Panicula unica scrutata circa 20 × 4 cm.; pedunculus ægre 13 cm. long.; rami primarii 5-10 mm., bracteæ ± 2 mm. long. Pedicelli ± 1·5 mm. long. Ovarium 2 mm., calyx ·5 mm. long. Corollæ in sicco atræ tubus 8 × 1 mm.; lobi 8 mm. long. Filamenta 2·5 mm., antheræ 7 mm. long. Stylus 11 mm., hujus rami 3 mm. long.

This is evidently close to *I. timorensis* Decne., its chief distinctive points being the lengthily acuminate leaves, the narrow inflorescence, and short thick pedicels to the flowers, together with the obtuse buds and broad corolla-lobes.

Morinda citrifolia Linn. Port Moresby (very common).

Psychotria decorifolia S. Moore, sp. nov.

Frutex glaber; *ramis* compressis (deinde verisimiliter subtetragonis striatulatis crebro foliosis; *foliis* brevipetiolatis elongatis lineari-lanceolatis longe gradatim acuminatis apice acutis basin versus leviter attenuatis basi obtusis punctis translucentibus minutis præditis pergamaceis costis lateralibus utrinque 16 pag. utravis inconspicuis; *stipulis* majusculis

ovatis fere usque medium in segmenta 2 anguste linearia divisis microscopice puberulis ; *floribus* parvis breviter pedicellatis in paniculam cymosam subracemiformem foliis breviorem vel tandem subæquilongam minute pubescentem postea fere glabram digestis cymulis pro verticello 3-4 pedunculatis paucifloris ; *ovario* cylindrico quam calyx cupularis 5-dentatus. paullulum longiore ; *corolla* parva extus glabra intus in faucibus dense albo-lanata lobis 5 late oblongis obtusis quam tubus paullo brevioribus ; *antheris* faucibus insertis vix exsertis ; *disco* optime prominente ; *stylo* glabro ramis obtusis microscopice papillosis ; *fructu* late ovoideo calyce coronato cocco utroque facile partibili dorso alte 4-sulcato glabro.

Sapphire Creek (No. 135).

Folia 22-24 × 3·4-4 cm., in sicco grisea ; petioli lati, 5 mm. long. Stipulæ 2·2 cm. long. (segmentis 1 cm. inclusis). Inflorescentia spec. alterius floriferi nobis obvii nondum profecto evoluta 7 cm. long., spec. alterius fructificantis 20 cm., hujus pedunculus vix 10 cm. long., rami primarii patentes cymulas sustinentes ± 1 cm. long. ; pedicelli sub floribus ovario circa æquilongi quam fructus vero plane breviores. Ovarium ·75 mm., calyx ·5 mm. long. Corollæ albæ tubus 2·5 mm., lobi 2 mm. long. Stylus 2·2 mm. hujus rami ·4 mm. long. Fructus albus, 5 mm. long.

The foliage and stipules are the chief characters of this distinct species.

P. mafuluensis S. Moore, sp. nov.

Arbuscula glabra ; *ramulis* validis compressis longitrorsum paucisulcatis ; *foliis* majusculis petiolatis oblongo-obovatis apice subito cuspidato-acuminatis (acumine brevi acuto) basi cuneatis pergamaceis costis lateralibus pag. inf. optime eminentibus utrinque circa 20 a costa medio angulo fere recto abeuntibus leviter arcuatis ; *stipulæ* late obovatis apice (anne semper ?) bidentatis dentibus triangularibus obtusis ; *paniculæ* terminali folia excedente laxe aperteque pauciramosa pedunculo valido compresso cymulis patentibus pro verticillo 2-3 laxe paucifloris ramis teneris insidentibus ; *floribus* parvis pedicellatis ; *ovario* turbinato calyce cupulari medium usque 5-lobo longiore ; *corollæ* parvæ triente sup. in lobos 5 late oblongos obtusos divisæ tubo cylindrico intus villoso ; *antheris* subsessilibus subexsertis ; *disco* prominente ; *styli* inclusi ramis obtusiusculis ; *fructu* adhuc valde crudo ovoideo calyce discoque onusto.

Mafulu (No. 416).

Folia in sicco griseo-brunnea, 18-21 × 7·5-10·5 cm., petiolis validis 2-3 cm. long. exemptis. Stipulæ 13 × 11 mm., in sicco fusco-brunneæ. Inflorescentia 22 × 15 cm. ; pedunculus 13 cm. long., uti rami ramulique albus ; pedicelli quoad longitudinem valde dissimiles, ± 3 mm. long. Ovarium ægre 1 mm., calyx ·4 mm.. ong. Corolla alba ; tubus 2·25 × 1 mm., lobi 1 mm. long. Antheræ 1 mm., stylus 1·5 mm. long., hujus rami ·75 mm. long. Fructus 3 × 2·3 mm.

In foliage very like *P. direpta* Wernh. except that the acumination is more sudden and the narrowed portion much shorter. Moreover the stipules are shorter and relatively broader as well as being bifid instead of entire. The flowers of *P. direpta* are unknown.

P. Whitei S. Moore, sp. nov.

Frutex novellis rufo-tomentosis : *ramulis* patentibus aliquanto compressis sursum foliosis rufo-tomentosis uti rami subteretes deinde glabrescentibus ; *foliis* breviter petiolatis ellipticis acuminatis apice obtusis basi breviter cuneatim angustatis pergamaceis supra glabris subtus in costis rufo-tomentosis alibi sparsim pubescentibus costis lateralibus utrinque 12-15 pag. inf. optime prominentibus parum arcuatis ; *stipulis* ovatis dorso rufo-tomentosis medium usque bilobis lobis triangularibus superne angustatis ; *panicula* laxa terminali foliis breviore uti flores pedicellique pallide fulvo-tomentosa ramis primariis pro verticillo sæpius 4 cymulis ramulosis plurifloris ultimis corymbosis ; *bracteis* parvis linearibus tomentosis ; *ovario* subgloboso calyce longiore ; *calycis* limbo 5-lobo lobis deltoideis obtusis ; *corollæ* usque medium in lobos 5 oblongos obtusos divisæ tubo cylindrico intus in faucibus piloso ; *stylo* glabro.

Dilava (No. 702).

Folia 13-15 × 4·5-6 cm., summa sæpissime 9-11 × 3·5-4·5 cm., horum acumen 1-1·5 cm. long., supra in sicco olivaceo-fusca ; petioli 5-10 mm. long. Stipulæ 12-14 mm. long., inferne 7 mm. in transversum. Panicula 8-10 × 4 cm. ; rami primarii infimi ± 17 mm. long., ascendentes. Bracteæ ± 2 mm. long. Pedicelli plerique ·5-1 mm. long. Ovarium ægre 1 mm., calyx ·5 mm. long. Corolla in toto 3·5 mm. long., tubus 1 mm. lat.

Affinity apparently with *P. rubiginosissima* Wernh., but entirely different in the foliage. In several particulars it answers the description of *P. Wichmannii*, Valet., but the venation of that species and the floral details are different.

Geophila reniformis D. Don. Javararie.

Amaracarpus cuneifolius Valet. (Det. by Dr. H. F. Wernham.) Dilava.

Hydnophytum sp. Koitaki (No. 409). Very close to *H. loranthifolium* Becc. but not quite conspecific. More flowers required for close determination.

Family CUCURBITACEÆ.

Macrozanonia macrocarpa Cogn. R. A. Rolfe, Kew Bull. 1920, 197-199; *Bignoniaceæ*, F. M. Bail. in Proc. Roy. Soc. Queens., xviii, p. 2 (1904). Mekeo District.

Mukia scabrella Arn. F. Muell. Pap. Pl. i (iv), 68. Yule Island.

Luffa cylindrica Rœm. (*L. ægyptiaca* Mill.); F. Muell. Pap. Pl., i (iv), 68; Bail. Queens. Agric. Journ., xxiii, 221. Ethel River (Mekeo District).

Family CAMPANULACEÆ.

Wahlenbergia gracilis A. DC. Mt. Warirata (Astrolabe Range). This plant is recorded by Mueller in Pap. Pl., ii (vi), 11, from Murray and Jervis Islands. Both these, however, are in Queensland territory.

Family GOODENIACEÆ.

Scævola Lauterbachiana Krause. Astrolabe Range and Dilava [S. E. New Guinea, *H. O. Forbes*, ex Nat. Herb. Melb.].

S. novoguineensis K. Sch. Astrolabe Range; Sogeri; Mafulu [near Port Moresby, *Rev. W. G. Lawes*, ex Nat. Herb. Melb.].

Family COMPOSITÆ.

Vernonia cinerea Less. F. Muell. Pap. Pl., i (ii), 27. Astrolabe Range; Sogeri; Mafulu.

Adenostemma viscosum Forst. F. Muell. Pap. Pl., i (iv), 69. Mafulu.

Ageratum conyzoides Linn. Port Moresby. A common weed.

Mikania scandens (Linn.) Willd. Sapphire Creek.

Erigeron linifolius Linn. F. Muell. Pap. Pl., i (iii), 44. Port Moresby. A very common weed.

Dichrocephala latifolia DC. *D. erecta* L'Her., F. Muell. Pap. Pl., ii (vi), 10. Mafulu.

Vittadinia brachycomoides F. Muell. Pap. Pl., ii (vi), 10; Vic. Nat. Feb. 1885. Astrolabe Range.

Blumea chinensis DC. Sapphire Creek and Mekeo District. A very common climber.

B. hieracifolia DC. F. Muell. Pap. Pl., i (v), 90. Yule Island.

B. lacera DC. Yule Island.

Pluchea indica Less. F. Muell. Pap. Pl., i (i), 10. Port Moresby. A very common beach shrub with strongly scented leaves and lavender-coloured flowers.

Pterocaulon cylindrostachyum C. B. Clarke. (*P. Billardieri*, F. Muell.); F. Muell. Pap. Pl., i (iii), 43.

Acanthospermum hispidum DC. Star Burr. Port Moresby. The plant is a great curse in Tropical Queensland.

Wedelia spilanthoides F. Muell. Port Moresby. A common weed in open forest country and native gardens.

Spilanthes Acmella Linn. Bisiatabu (Astrolabe Range).

Synedrella nodiflora Gærtn. Port Moresby. A common weed.

Bidens pilosa Linn. F. Muell. Pap. Pl., i (iii), 42. Cobbler's-pegs. Port Moresby. A common weed.

Crepis japonica Benth. F. Muell. Pap. Pl., ii (vi), 11. Bella Vista (ca. 5,000 ft.).

APPENDIX.

LORANTHACEÆ RECORDED FOR NEW GUINEA AND ADJACENT ISLANDS.

By W. F. Blakeley (Botanical Assistant, Botanic Gardens, Sydney).

Family LORANTHACEÆ.

Elytranthe Blume in Shults f. Syst., vii, 2.

Sect. ?

Elytranthe suberosa Laut. in Nov. Guinea, viii, pt. 4, 816 (1912). Dutch New Guinea, Biwak Hollandia (Humboldt-Bai.). Gjellerup No. 96, 30th April, 1910; No. 148, 28th May, 1910.

Sect. III.—Amylotheca van Tiegh.

E. Hollrungii K. Sch. in Fl. Kaiser Wilhelm's Land, 105 (1889). Engl. in Nach. ii, iv, Teil. 126 (1879). Allied to (*E. L.*) *dictyophleba*; Ramufluss (Tappenbeck No. 69, June 1898).

LORANTHUS L.

Subgenus I.—EULORANTHUS Engl.

Sect. I.—DACTYLOPHORA van Tiegh.

Loranthus verticellatus (Scheff.). Benth. et Hook. in Gen. Plant, iii, 208. (*Dendrophthœ verticellatus* Scheff., in Ann. Jard. Bot. Buitenz. i, 37.) Also recorded by Mueller in Descriptive Notes on Papuan Plants, i. (v) 99 (1875).

L. strongylophyllus Laut. in Nov. Guinea, Biwak, Hollandia (Humboldt-Bai.). Gjellerup No. 307, 18th Aug. 1910.

L. Versteegii Laut. in Nov. Guinea, viii, 289 (1910). Dutch New Guinea, Noord-Fluss, bei Alkmaar Urwald. (Versteeg. No. 1506, 23rd July, 1907); Noord Fluss, Biwak, Zwaluw, Uferwald (Versteeg, No. 1801, 8th Oct. 1907); Bian Fluss (Branderhost No. 278, 12th Dec. 1907). Manokœari, Miss L. S. Gibbs in Phytog. Fl. Arfak Mts. 210 (1917); South New Guinea, Geluks-Hugel. Urwald (V. Roemer No. 473, 7, 1909).

Sect. II.—HETEROSTYLIS Benth.

Series I.—EUAMYEMA.

A. UMBELLULATI.

L. Friesianus K. Sch. in Schum & Lauterb.. Fl. Deutsch. Schutzg. Sudsee, 258 (1905). Kaiser Wilhelm's Land; Stephansort; Gestade (Nyman No. 41, 23rd Dec. 1898).

B. CYMULATI.

L. caudiciflorus Laut. in Nov. Guinea, viii, 290 (1910). Dutch New Guinea, Noord-Fluss, bei Gertenkamp (Versteeg No. 1473, July 1907).

L. pachypus Burkill in Kew Bull. 109 (1899). Allied to *L. pendulus* Sieb. Mt. Scratchley, 1,000-1,300 ft. [A. Guilianetti.]

Series ?

L. oxycladus Laut. et K. Sch. in Fl. Deut. Schutzg Sudsee, 298 (1901). Kaiser Wilhelm's Land; Suve-Mana bei Ssigdum-Jana, Hockwald. (M. Lauterbach No. 2276, June 1896); (Nurufiusse, No. 2328, June 1896); New Mecklenburg (Schlecter No. 14645, July 1902).

L. novæ-brittaniae Laut. in Nachtr. Fl. Deut. Sudsee, 259 (1905). Ins. Bismark, Neu-Pommern, bei Mandres (Schlecter No. 13765, Nov. 1901); Neu-Mecklenburg (Schlecter No. 14691). Peiana.

L. novæ guinæ Bail. in Ann. Rept. B.N.G. 1900-1, p. 144. Goodenough Island, *G. R. Le Hunte.*

Sect. X.—DIPLATIA van Tiegh.

L. Albertisii (van Tiegh) Engl. in Engl. & Prantl. Pflanzenf Nachtr. 1. 129. Recorded for New Guinea without specific locality. This species is allied to *L. grandibracteus* F. v. M.

Subgenus II.—DENDROPHTHŒ Mart.

Series 2.—CICHLANTHUS Engl.

L. diversifolius Ridl. in Trans. Linn. Soc. Lond. (Bot.) vol. ix, pt. i, p. 146 (1916). Dutch New Guinea, Camp III to IX, 2,500 to 5,500 ft. Wollaston Expedition.

L. hastifolius Ridl. l.c. Camp VII to VIII, 3,660 to 4,900 ft. Wollaston Expedition.

Series 3.—EUDENDROPHTHŒ.

L. longiflorus Desr. Neu Pommern, Bei Massawa (Schlecter No. 13741, 1901); South New Guinea, Flachland, Urwald (V. Roemer No. 473, Sept. 1909); Kaiser Wilhelm's Land; Halzfelden (Hollrung No. 342); Augusrafluss (Hollrung No. 662); Ramufluss (Tappenbach No. 114, 14th July, 1898). Dutch New Guinea; Wollaston Expedition, Camp III, 2,500 ft.; Ridl. Bot. Woll. Exped. Trans. Linn. Soc. Lond. 2 ser., vol. ix, pt. 1, p. 146 (1916).

Series ?

L. dolichocladus K. Sch. in Nach. Fl. Deutsch. Sudsee, 258 (1905). Kaiser Wilhelm's Land and Frederick Wilhelmshafen (type locality); (Nyman No. 1068, Sept. 1899). Dutch New Guinea, Sudkuste bei Merauke, Alagfalern (Versteeg No. 1909, Nov. 1907).

L. Lauterbachii K. Sch. in Fl. Deutsch. Sudsee, 299 (1901). Kaiser Wilhelm's Land, Am Huon-Golf bei Kap Ankona (Lauterbach No. 666, Aug. 1890—the type). Dutch New Guinea, Noord-Fluss (Versteeg No. 1798, Oct. 1907, No. 1033, March 1907).

L. Gjellerupii Laut. in Nov. Guinea, viii, 815 (1912). Dutch New Guinea, Biwak Hollandia (Humboldt-Bai Seestrand Gjellerup No. 143, May 1910).

L. Seemenianus K. Sch. in Fl. Kaiser Wilhelm's Land, 106 (1889). Seestrand von Halyfeldthafen (Hollrung No. 345, Oct. 1887).

L. Balmeri Laut. et K. Sch. in Fl. Deut. Schutzg Sudsee 278 (1901). Kaiser Wilhelm's Land, Sattelberg (Balmer No. 16).

L. finisteriæ Warb. in Bergpfl. 13, 20 (1892). Kaiser Wilhelm's Land, Finisterre-Gebirge (Hellwig No. 322, Oct. 1888).

Loranthus sp. near *L. alyxifolius* F. v. M. Recorded by Bailey in Queens. Agric. Journ., vii, 349.

Loranthus sp. Valeton, Bull. Dept. d. l. Agric. Ind. Neerland. x, 7.

FAMILY VISCOIDEÆ.

NOTOTHIXOS Oliv.

Sect. I.—EUNOTOTHIXOS van Tiegh.

Notothixos leiophyllus K. Sch. Nach. Fl. Deutsch. Schutz. Sudsee, 260 (1905). Bismark-Archipel New Pommern (*R. Parkinson*, No. 105 (1885)). This is the plant referred to by Mueller in Notes Papuan Plants, ii (7), 29 (1886), under *N. subaureus*, "in a large-leaved state with more elongated inflorescence"; and also in Pap. Pl., ii, 61, and Linn. Soc., vol. ii, n.s., p. 422. Base of Owen Stanley Ranges. British New Guinea (*H. O. Forbes*, No. 779 (1885-6)).

I am indebted to Professor Ewart, of the Melbourne Herbarium, for the loan of the last three specimens.

VISCUM L.

Sect. I.—PLOINIXIA Korth.

Series I.—ISANTHEMUM van Tiegh.

Viscum orientale Willd. is recorded for Papua by Mueller in Descriptive Notes on Papuan Plants, p. 99 (1875), who quoted Scheffer's record in Bot. Gard. Buitenzorg. vi, p. 27. Scheffer's record is as follows (*V. orientale* Willd. Miq. l.c. p. 804) :—I have not seen this specimen and therefore cannot say if it is the same as *V. verruculosum* Wight & Arn. C. Lauterbach in Flora Nov. Guinea, vol. viii, pt. iv, p. 816 (1912), records it for Dutch New Guinea : Biwak Hollandia (Humboldt-Bai) on sea-strand (Gjellerup No. 105, Feb. and April (1910)).

Sect. II.—ASPIDIXIA.

V. angulatum Heyne. Islands on the south coast of New Guinea (*Rev. J. Macfarlane* 1885), Mueller in Notes Papuan Pl. ii (ix), 29 (1886). According to Professor Ewart this species is not represented in the Papuan collection in the Melbourne Herbarium.

Principal Bibliography of Works on the Flora of the Territory of Papua (British New Guinea).

1875-1877. MUELLER, Baron FERD. VON.—Descriptive Notes on Papuan Plants. Pts. i-v forming vol. i. Pts. vi-ix, forming the first four parts of vol. ii, were issued from 1885 to 1890. The volume was not completed nor an index issued.

1877-1890. BECCARI, O.—Malesia, vols. i, ii, and iii. Contains descriptions of a few of D'Albertis' plants from the Fly River.

1880. BECCARI, O.—Notes on Plants Collected by Sig. L. M. D'Albertis in New Guinea, in "New Guinea" by D'Albertis, pp. 391-400. All the plants listed are from the Fly River.

1882. MUELLER, Baron FERD. VON.—A Gesneriaceous Plant discovered in New Guinea. Wing's "Southern Science Record," vol. ii, p. 229.

1884-5. MUELLER, Baron FERD. VON.—Several small papers in the Melbourne "Chemist and Druggist."

1884-1896. MUELLER, Baron FERD. VON.—Miscellaneous Papers in the "Victorian Naturalist," vols. i-xiii.

1885. MUELLER, Baron FERD. VON.—Descriptive Notes on Papuan Plants. Two papers in "The Australasian Scientific Magazine."

1885-1886. MUELLER, Baron FERD. VON.—Several Papers in Wing's "Southern Science Record," vols. i and ii (new series).

1886. RIDLEY, H. N.—On the Monocotyledonous Plants of New Guinea, collected by Mr. H. O. Forbes. Journ. Botany, vol. xxiv pp. 321-327 and pp. 353-360.

1886-7. MUELLER, Baron FERD. VON.—Several small papers in the "Australasian Journal of Pharmacy."

1887. MUELLER, Baron FERD. VON.—Report on a Small Collection of Plants from the Aird River, obtained by Mr. Theodore Bevan. Proc. Linn. Soc. N.S.W., vol. ii, n.s., pp. 419-422.

1887. MAIDEN, J. H.—Notes on Some Indigenous Sago and Tobacco from New Guinea. Proc. Linn. Soc. N.S.W., vol. ii, n.s., pp. 457-466.

1888-1896. MUELLER, Baron FERD. VON.—Papers in Annual Reports, British New Guinea.

1889. MUELLER, Baron FERD. VON.—Records of Observations on Sir Wm. MacGregor's Highland Plants from New Guinea. Trans. Roy. Soc. Vic., vol. i, pt. 2, pp. 145.

1892. Succinct General Notes on the Flora of British New Guinea. Appendix ii to J. P. Thomson's "British New Guinea," pp. 218-221.

1891-3. MUELLER, Baron FERD. VON.—Notes on Papuan Plants. Three papers in the "Journal of Botany," vols. xxix-xxxi.

1896. BAILEY, F. M.—Additions to the New Guinea Flora. Botany Bulletins xiii and xiv (Queensland Dept. Agriculture), pp. 14-16

1897-1914. BAILEY, F. M.—Contributions to the Flora of British New Guinea. A series of papers published in the "Queensland Agricultural Journal."

1898. BAILEY, F. M.—Names of Easily Recognised Plants observed by Lord Lamington's Party during New Guinea Expedition. Appendix (pp. 27-28) of Parliamentary Paper "Report of Visit to British New Guinea."

1898. HEMSLEY, W. B.—Report on Botanical Collections. Annual Report British New Guinea 1897-8, pp. 147-150.

1899. BAILEY, F. M.—Notes on the Vegetation of New Guinea. Proc. Roy. Soc. Queensl., xiv, pp. 14-20.

1899. HEMSLEY, W. B., and others.—Flora of British New Guinea. Kew Bull. 1899, pp. 95-126.

1899-1901.—BAILEY, F. M.—Papers in Annual Reports, British New Guinea (reprinted from the "Queensland Agricultural Journal").

1904. BAILEY, F. M.—Contributions to the New Guinea Flora. Proc. Roy. Soc. Queensl., xviii, pp. 1-5.

1905. SCHUMANN, K., and LAUTERBACH, K.—Nachträge Flora Deutsch. Schutzgeb. Sudsee. Contains a few references to plants from British New Guinea.

1908. BURNETT, GILBERT.—Timber Trees of the Territory of Papua (Issued by the Dept. of External Affairs, Melbourne).

1911. COPELAND, E. B.—Papuan Ferns collected by the Rev. Copland King. Philippine Journ. Science. Bot., vol. vi, pp. 65-92.

1912-1916. LAUTERBACH, SCHLECHTER, and others.—Beiträge zur Flora von Papuasien, i-v. Contains many references to plants from British New Guinea.

1916. RIDLEY, H. N., and others.—Report on the Botany of the Wollaston Expedition to Dutch New Guinea. Trans. Linn. Soc. (Bot.), vol. ix, pp. 1-269. Contains a few odd references to plants from British New Guinea.

1918. WERNHAM, H. F.—Dr. H. O. Forbes's New Guinea Rubiaceæ. Journ. Bot., vol. lvi, pp. 68-77 and pp. 129-135.

1922. DIXON, H. N.—The Mosses of the Wollaston Expedition to Dutch New Guinea 1912-13, with some additional Mosses from British New Guinea.—Jour. Linn. Soc. (Bot.), vol. xlv, pp. 477-510.

Marine Mollusca from New Guinea.

By JOHN SHIRLEY, D.Sc., F.M.S., Corresponding Member, Royal Society of Tasmania; Honorary Member, Pharmaceutical Society of Queensland.

(*Read before Royal Society of Queensland, 11th April, 1922.*)

IN a recent visit to New Guinea, Professor J. V. Danes, Ph.D., Consul-General for Czecho-Slovakia, travelled in British Papua, and in the mandated territory lately known as German New Guinea. He was accompanied by his charming and accomplished wife, who at Samarai, Gurya Beach, Rabaul, and Port Moresby made collections of marine shells. These were submitted to me for determination, and a classified list is shown herewith. As the time spent at each place of call was limited, few of the smaller species were gathered, and the list reveals few novelties.

The first collection of New Guinea Mollusca seems to have been made in 1842-6, when H.M.S. "Fly," under Captain F. R. Blackwood, was employed in surveying the North Australian and South Papuan coasts. On board this ship was Dr. J. Beete Jukes, who diligently searched for mollusca on all possible occasions. His collections were described mainly by Arthur Adams and Lovell Reeve, while Dr. J. E. Gray dealt with certain important discoveries in an appendix to Jukes's narrative.

This survey was continued and extended by H.M.S. "Rattlesnake" in 1849-50, when the Louisiade Islands were visited and collections made, to be afterwards described by Forbes in an appendix to MacGillivray's account of the voyage. The "Challenger" while in Torres Strait, at Station 188, on 10th September, 1874, dredged off south-west of Papua. An expedition organized in 1875 by Sir William Macleay left Sydney in the "Chevert," having on its scientific staff such well-known Australian workers as Messrs. Brazier, Masters, Petterd, and Spalding; and called at Yule Island where Brazier gathered many new species of shells, whose descriptions, with those from Australian localities, will be found in his numerous papers in series 1, vols. 1 and 2 of the Linnean Society's Proceedings,[1] New South Wales. During 1875 and following

[1] *See also* vol. ix, pp. 988-992, and vol. x, pp. 841-4, first series.

years, D'Albertis obtained at Yule Island and the Fly River a great supply of conchological material, that was submitted to Tapparone-Canefri, and published in the Annali del Museo Civico di Genova, vol. xix, first series, and iv, second series.

Mr. A. Goldie, a trader and collector, travelled extensively in south-eastern New Guinea, and collected land and marine shells, that went mainly to the British Museum, and were described by the late E. A. Smith in the Annals and Magazine of Natural History. Professor A. C. Haddon, during his expedition to Torres Strait, on 17th August, 1888, dredged in the channel between Saibai and New Guinea. His molluscan gatherings were submitted to Messrs. Melvill and Standen, who published their results in the Journal of the Linnean Society, London, vol. xxxvii. 1899, pp. 150-206, with two plates.

A collection made by Sir William Macgregor in the Louisiades in 1889 was also sent to the conchologist of the British Museum for naming and describing. In 1890 Mr. Charles Hedley of the Sydney Museum was in New Guinea for three months, the guest of Sir William Macgregor. He was given opportunities to visit Milne Bay, Samarai, Port Moresby, and St. Joseph's River, mainly in search of land shells. His gatherings are described in the Proceedings of the Linnean Society of New South Wales, vol. vi, second series, 1891, pp. 67-116; and vol. ix, pt. 2, pp. 384-92.

Papers on species of *Chloritis*, by S. K. Gude, including some from New Guinea and neighbouring islands, will be found in the Proceedings of the Malacological Society, vol. vii, pt. 1, pp. 44-48, and pt. 2, pp. 105-8.

Sub-Kingdom MOLLUSCA.

Class PELECYPODA (1–35).

Order PRIONODESMACEA (1–15).

Family ARCIDÆ.

Arca, Linné Syst. Nat., x, 1758, p. 693.

1. *Arca chalcantha* Reeve. 3.
2. *Arca fusca* Bruguieres. 1.
3. *Arca imbricata* Bruguieres. 2.
4. *Arca lima* Reeve. 3.
5. *Arca trapezia* Deshayes. 1, 2, 3.

The numerals after the species refer to the following localities:—
1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

GLYCIMERIS da Costa, Brit. Conch., 1778, p. 168.

6. *Glycimeris montrouzeri* Angas. 1.
7. *Glycimeris pectunculus* Linné = *pectiniformis*, Lamarck. 1.
8. *Glycimeris reevei* Mayer = *angulata* Reeve. 1.

FAMILY PERNIDÆ.

PERNA Bruguieres, 1792.

9. *Perna sulcata* Lamarck. 1.

FAMILY PECTENIDÆ.

CHLAMYS Bolten, Mus. Bolten, 1798, p. 161.

10. *Chlamys pallium*, Linné. 1.

FAMILY SPONDYLIDÆ.

SPONDYLUS Linné, Syst. Nat., x, 1758, p. 690.

11. *Spondylus depressus* Fulton. 1, 3.
12. *Spondylus hystrix* Bolten *non* Reeve. 1, 2.
13. *Spondylus nicobaricus* Chemnitz. 1.

MODIOLUS Lamarck, Mem. Soc. N. H. Paris, 1799, p. 87.

14. *Modiolus philippinarus* Hanley. 4.

SEPTIFER Recluz, Rev. Zool., 1848, p. 275.

15. *Septifer bilocularis*, Linné. 3.

ORDER TELEODESMACEA (16-35).

FAMILY CARDITIDÆ.

CARDITA Bruguieres, Encyc. Meth. vers (2), 1792, p. 401.

16. *Cardita variegata* Bruguieres. 1.

FAMILY CHAMIDÆ.

CHAMA Linné, Syst. Nat., x, 1758, p. 691.

17. *Chama pacifica* Brod. 3.

The numerals after the species refer to the following localities:—
1 Samarai, 2 Guyra Beach, 3 Rabaul, 4 Port Moresby.

Family LUCINIDÆ.

Corbis Cuvier, Regn. Anim., ii, 1817, p. 480.

18. *Corbis fimbriata* Linné. 4.

Family CARDIIDÆ.

Cardium Linné, Syst. Nat., x, 1758, p. 678.

19. *Cardium reevianum* Dunker. 1, 2, 3.

Family TRIDACNIDÆ.

Tridacna Bruguieres, 1789.

20. *Tridacna crocea* Lamarck. 2.

Hippopus Linné, Syst. Nat., x, 1758, p. 691.

21. *Hippopus hippopus* Linné. 1, 3, 4.

Family VENERIDÆ.

Lioconcha Mörch, Cat. Yoldi, ii, 1853, p. 26.

22. *Lioconcha castrensis* Linné. 1, 2.

Gafrarium Bolten Mus Bolt., 1798, p. 176.

23. *Gafrarium australis* Sowerby. 3.
24. *Gafrarium australica* Reeve. 1, 3, 4.
25. *Gafrarium pectinatum* Linné. 2, 3, 4.
26. *Gafrarium tumidum* v. *ranellum* Lamarck. 2, 3.

Antigona Schumacher, Essai Nouv. Syst., 1817, p. 51.

27. *Antigona puerpera* v. *gladstonensis* Menke. 1.
28. *Antigona toreuma* Gould. 2.

Paphia Bolten, Mus. Bolt., 1798, p. 175.

29. *Paphia variegata* Bruguieres. 1.

Family PLEUROPHORIDÆ.

Trapezium Desh. Trait. Ellem. Conch., ii, p. 18.

30. *Trapezium angulatum* Lamarck. 1.

The numerals after the species refer to the following localities :—
1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

FAMILY TELLINIDÆ.

TELLINA Linné, Syst. Nat., x, 1758, p. 674.

31. *Tellina virgata.* 3.

FAMILY GARIDÆ.

ASAPHIS Modeer, K. Vet. Ac. Nya Handl. xiv, 1793, p. 176.

32. *Asaphis deflorata* Linné. 1, 3, 4.

FAMILY AMPHIDESMATIDÆ.

AMPHIDESMA Lamarck, An. s. vert., v, 1818, p. 489.

33. *Amphidesma plana* Hanley. 1, 3.
34. *Amphidesma striata* Gmelin. 1, 2, 3.

FAMILY CORBULIDÆ.

CORBULA Brug., Encyl. Meth., 1797, tab. vers. pl. 230.

35. *Corbula scaphoides* Hinds. 3.

CLASS GASTEROPODA (36–135).

ORDER DIOTOCARDIA (36–57).

FAMILY HALIOTIDÆ.

HALIOTIS Linné, Syst. Nat., x, 1758, p. 779.

36. *Haliotis varia* Linné. 1.

FAMILY TROCHIDÆ.

MONODONTA Lamarck, Mem. Soc. N. H. Paris, 1799, p. 74.

37. *Monodonta tuberculata* A. Ad. 2.

TROCHUS Linné, Syst. Nat., x, 1758, p. 756.

38. *Trochus obeliscus* Linné. 1.
39. *Trochus venustus* Reeve. 1.

FAMILY TURBINIDÆ.

TURBO Linné, Syst. Nat., x, 1758, p. 761.

40. *Turbo chrysostomus* Linné. 1.
41. *Turbo intercostalis* Menke. 1.
42. *Turbo petholata* Reeve. 1.
43. *Turbo porphyrites* Martyn. 1.
44. *Turbo radiatus* Gmelin. 1.

The numerals after the species refer to the following localities:—
1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

ASTRÆA Bolten, Mus. Bolt., 1798, p. 79.

45. *Astræa hæmotraga* Menke. 1.
46. *Astræa nobilis* Gray. 1.

CHRYSOSTOMA Swainson, 1840.

47. *Chrysostoma paradoxam* Born. 1.

FAMILY NERITIDÆ.

NERITA Linné, Syst. Nat., x, 1758, p. 776.

48. *Nerita albicilla* Linné. 1, 2.
49. *Nerita costata* Chemnitz. 1.
50. *Nerita planispira* Anton. 1.
51. *Nerita plicata* Linné. 1.
52. *Nerita polita* Linné. 1, 2.
53. *Nerita polita* v. *rumphii* Recluz. 1.
54. *Nerita signata* Macleay. 2, 3.
55. *Nerita reticulata* Karstens. 1.
56. *Nerita* [2]*semirugata* ? Recluz. 3.
57. *Nerita undata* Linné. 1, 3.

ORDER MONOTOCARDIA (58–135).

SUBORDER TÆNIOGLOSSA (58–96).

FAMILY LITTORINIDÆ.

MELARAPHE Menke, Syn. Meth. Moll., 1828, p. 45.

58. *Melaraphe scabra* Linné. 2.
59. *Melaraphe scabra* v. *sinensis* Philippi. 2.

FAMILY PLANAXIDÆ.

PLANAXIS Lamarck, 1822.

60. *Planaxis sulcatus* Born. 3.

FAMILY HIPPONICIDÆ.

HIPPONIX Defrance, Bull. Soc. Philom., 1819, p. 8.

61. *Hipponix barbatus* Sowerby. 1.

FAMILY CAPULIDÆ.

CAPULUS Montfort, Conch. Syst., ii, 1810, p. 55.

62. *Capulus tricarinatus* Linné. 3.

The numerals atter the species refer to the following localities :—
1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

[2] These shells agree completely with specimens so named by Brazier; and with f. 41, plate 3, vol. x of Tryon; but differ in outline and lip details from f. 42 of the same plate.

FAMILY CERITHIIDÆ.

CERITHIUM Bruguieres, Encyc. Meth. vers (1), 1789, p. xv.

63. *Cerithium gemmulatum* Hinds. 1.
64. *Cerithium gemmulatum* v. *articulatum* H. & A Adams. 1.
65. *Cerithium janelli* H. & J. 2.
66. *Cerithium janelli* v. *moniliferum* Sowerby. 2.

FAMILY STROMBIDÆ.

STROMBUS Linné, Syst. Nat., x, 1758, p. 742.

67. *Strombus dentatus* Linné. 1, 3, 4.
68. *Strombus gibberulus* Linné. 2.
69. *Strombus luhuanus* Linné. 1, 2.
70. *Strombus minimus* Linné. 3, 4.

FAMILY CYMATIIDÆ.

CYMATIUM Bolten, Mus. Bolt., 1798, p. 129.

71. *Cymatium testaceum* Mörch. 1.

FAMILY CASSIDIDÆ.

PHALIUM Link, Rostock Samml., iii, 1807, p. 112.

72. *Phalium vibex* Linné. 3.

FAMILY NATICIDÆ.

NATICA Scopoli, Intr. Hist. Nat., 1777, p. 392.

73. *Natica deidosa* Reeve. 1.
74. *Natica flemingiana* Recluz. 1.
75. *Natica gualteriana* Recluz. 2.
76. *Natica mamilla* Reeve. 2.
77. *Natica* [3]*mozaica* Sowerby. 3.

POLINICES Montfort, Conch. Syst., ii, 1810, p. 222.

78. *Polinices filosa* Sowerby. 2.

FAMILY MODULIDÆ.

MODULUS Gray, 1840.

79. *Modulus tectum* Gmelin. 1.

The numerals after the species refer to the following localities :—
1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

[3] Only one specimen was included in Madame Danes's collection ; it is typical in size and shape, but the first circle of spots on the body-whorl is more distant from the second one than is usual.

Family CYPRÆIDÆ.

Cypræa Linné, Syst. Nat., x, 1758, p. 718.

80. *Cypræa annulus* Linné. 2, 3, 4.
81. *Cypræa asellus* Linné. 1.
82. *Cypræa caput-serpentis* Linné. 1.
83. *Cypræa caurica* Linné. 1.
84. *Cypræa cicerula* Gmelin. 1, 3.
85. *Cypræa erosa* Linné. 1, 3, 4.
86. *Cypræa errones* Linné. 1, 3.
87. *Cypræa felina* Gmelin. 1.
88. *Cypræa interrupta* Gray. 1.
89. *Cypræa isabella* Linné. 1, 2, 3.
90. *Cypræa lynx*. 1, 2, 3.
91. *Cypræa moneta* Linné. 1, 3.
92. *Cypræa neglecta* Sowerby. 1, 2.
93. *Cypræa nucleus* Linne. 1, 2.
94. *Cypræa quadrimaculata* Gray. 1, 2.

Trivia Broderip, Penny Cycl., viii, 1837, p. 256.

95. *Trivia insecta* Mighels. 1.
96. *Trivia oryza* Lamarck. 1, 2.

Suborder STENOGLOSSA (97–135).

Family OLIVIDÆ.

Oliva Bruguieres, Encyc. Meth. vers, i, 1789, p. xv.

97. *Oliva australis* Ducloz. 3.
98. *Oliva bulowi* Sowerby. 3.
99. *Oliva carneola* Gmelin. 3.
100. *Oliva duclosi* Reeve. 3.

No. 98. A shell of 8 whorls, having the general shape of *O. australis* Ducl., and an average specimen measuring 23 cm. × 10 cm. The mouth is 17 cm. × 5 cm., but unlike *australis* its posterior canal is closer to the body-whorl. The ground colour is tawny yellow, marked by faint chestnut-coloured spots on the upper half of the body-whorl; these increase in size and depth of colour, and form zigzag streaks below.

No. 100. Very closely resembles *O. ispidula* L., of which it may be a variety. It differs in size, being usually smaller, and in the shape of the mouth. In *ispidula* the space between the two lips widens gradually from above down ward. In *duclosi* for two-thirds of the length the lips are nearly parallel. Then the inner lip slopes rapidly. The ground colour of the shell is lighter, and the striations on the columella more numerous.

The numerals after the species refer to the following localities :—
1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

FAMILY CONIDÆ.

CONUS Linné, Syst. Nat., x, 1758, p. 712.

101. *Conus achatinus* Chemnitz. 1.
102. *Conus auratus* Lamarck. 1.
103. *Conus ceylonensis* v. *nanus* Brot. 1.
104. *Conus emaciatus* Reeve. 1.
105. *Conus glans* Hwass. 1.
106. *Conus hebræus* Linné. 1.
107. *Conus militaris* Hwass. 1.
108. *Conus musicus* Hwass. 1.
109. *Conus mussatella* Linné. 1.
110. *Conus omaria* Hwass. 1.
111. *Conus* [4]*pulchellus* Swainson. 1.
112. *Conus rattus* Hwass. 1, 2, 3.
113. *Conus stercus-muscarum* Linné. 1.
114. *Conus* [5]*varius*, Linné. 1.

FAMILY TURRIDÆ.

DRILLIA Gray, 1838.

115. *Drillia digitalis* Reeve. 1.

FAMILY TURBINELLIDÆ.

LATIRUS Montfort, 1810.

116. *Latirus turritus* Gmelin. 3.

PERISTERNIA Mörch, 1852.

117. *Peristernia nassatula* Lamarck. 1.

VASUM Bolten, 1798.

117A. *Vasum armigerum* Brod. 1.

The numerals after the species refer to the following localities:—
1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

[4] The specimen from Samarai resembles f. 78 of plate 14 of Tryon's Manual in size, spire, and markings, except that the central light band is moie definite and complete.

[5] A rare shell on the Queensland coast and seldom collected in a perfect condition. The New Guinea specimen agreed in outline, in the tubercles on the spire, and showed the remains of the grooves on the lower half of the body-whorl. The ground colour was white, with remains of chestnut patches.

FAMILY MITRIDÆ.

MITRA Martyn, Univ. Conch., 1784, Expl. to p. 19.

118. *Mitra amanda* Reeve. 1.
119. *Mitra auriculoides* Reeve. 1.
120. *Mitra cucumerina* Linné. 1.
121. *Mitra paupercula* Linné. 2.
122. *Mitra tabanula* Lamarck. 1.
123. *Mitra rufescens* A. Adams. 2.
124. *Mitra stictica* Link = *cardinalis* v. *pertusa* Sowerby.

FAMILY BUCCINIDÆ.

CANTHARUS Bolten, 1798.

125. *Cantharus rubiginosus* Reeve. 1.

FAMILY NASSARIIDÆ.

NASSARIUS Froriep in Dumeril, Zool. Analyt., 1806, p. 167.

126. *Nassarius jonasi* Dunker. 3.

FAMILY PYRENIDÆ.

PYRENE Bolten, Mus. Bolt., 1798, p. 134.

127. *Pyrene fulgurans* Lamarck. 1.
128. *Pyrene punctata* Bruguieres. 1, 2.
129. *Pyrene versicolor* Menke. 1.
130. *Pyrene Zelina* Ducloz. 1.

FAMILY MURICIDÆ.

MUREX Linné, Syst. Nat., x, 1758, p. 746.

131. *Murex australiensis* A. Adams. 1.

FAMILY THAIDIDÆ.

THAIS Bolten, Mus. Bolt., 1798, p. 54.

132. *Thais ambustulata* Hedley. 1.
133. *Thais pica* Blainville. 1.

The numerals after the species refer to the following localities :—
1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

DRUPA Bolten, Mus. Bolt., 1798, p. 55.

134. *Drupa mora* Bolten. 1.

135. *Drupa ochrostoma* Blainville. 2.

SUBORDER PULMONATA (136–142).

FAMILY ELLOBIIDÆ.

PYTHIA Schumacher, 1817.

136. *Pythia argenvillei* Pfeiffer. 3.

137. *Pythia pantherina* A. Adams. 4.

RHODOSTOMA Swainson, Proc. Roy. Soc., V.D. Land, iii, 1855, p. 44.

138. *Rhodostoma nucleum* Martyn. 2.

MELAMPUS Montfort, 1840.

139. *Melampus lividus* Deshayes. 2.

FAMILY SIPHONARIIDÆ.

SIPHONARIA Sowerby, Genera of Shells, 1824, fasc. xxi.

140. *Siphonaria acuta* Quoy & Gaimard. 1.

141. *Siphonaria atra* Quoy and Gaimard. 1.

142. *Siphonaria zebra* Reeve. 1.

SUBORDER OPISTHOBRANCHIA (143–144).

FAMILY SCAPHANDRIDÆ.

ATYS Montfort, 1810.

143. *Atys cylindrica* Helbling. 4.

FAMILY AKERIDÆ.

BULLARIA Rafinesque, Anal. Nat, 1815, p. 142.

144. *Bullaria adamsi* Menke. 1, 2.

The numerals after the species refer to the following localities:— 1 Samarai, 2 Gurya Beach, 3 Rabaul, 4 Port Moresby.

Notes on the Biology of some of the More Common Queensland Muscoid Flies.

By Professor T. Harvey Johnston, M.A., D.Sc., and O. W. Tiegs, M.Sc., formerly Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(Read before Royal Society of Queensland, 28th April, 1922.)

The main object of the present paper is to place on record the results of a series of observations which aimed at determining the duration of the various stages of the life-cycle of some of the common Queensland Muscoid flies. Amongst those dealt with are the housefly; a number of blowflies including certain sheep maggot-flies; some species of *Sarcophaga* and *Musca*; and the stable fly *Stomoxys*.

Observations were recorded regarding the following:—Length of time taken by the egg to hatch; period during which the larva fed; time intervening between the cessation of feeding and the undergoing of obvious pupation (larval resting period or prepupal stage); length of time passed in the pupal condition; time elapsing between the deposition of a larva or egg and the emergence of the imago resulting from such larva or egg; the period between emergence and sexual maturity of the female as evidenced by the act of copulation (maturation period); time between emergence of the female and oviposition by it (preoviposition period); longevity of the adult in captivity.

The egg period was always obtained by observing the fly actually ovipositing and watching till the eggs hatched, the time being noted in hours. No attempt was made to ascertain the length of time passed in the various larval instars. The resting period was regarded as commencing when the larvæ began to leave their food material and to wander. This wandering is a marked characteristic of some of the species—e.g. *Lucilia* larvæ are capable of travelling many yards from the place of feeding until they find a suitable patch of soil in which to pupate; while *Chrysomyia albiceps* and *Sarcophaga* spp. likewise may wander for a considerable distance; on the other hand *Ophyra nigra* generally bores into the soil directly beneath, or in close proximity to, its feeding place.

Male flies appear to be sexually mature soon after emergence from the puparium, but females usually take some time

to reach maturity, the time being reckoned as from the date when copulation was observed to occur, as this no doubt takes place soon after the flies are mature. The determination of the length of adult life of the various flies, as recorded in this paper, is not very satisfactory since the insects had necessarily to be kept in confinement from the time of their emergence. Food, temperature, moisture, etc., all influence this period.

There are unfortunately numerous blanks in the tables given in this paper, some of them owing to the fact that a number of the flies would not copulate in captivity, though they were flying about in a large room with abundant bright and shady places in it. During the summer it was found possible to carry out monthly observations, but this could not be done in the winter, owing to the difficulty of obtaining suitable species when needed. As the length of the various periods in the case of *Lucilia* was ascertained to be fairly constant during the several winter months, it has been considered sufficient in most cases to record observations during the winter period (May to September) without specifying any particular months.

A curious fact noted was that while *all* the species of carrion-flies could be obtained during any month yet many species had a period during which they gradually increased in numbers relatively and eventually predominated over the other species.

The observations to be referred to, unless otherwise stated, were carried out in Brisbane from the beginning of September 1920 till the end of August 1921, i.e. a full year. Some observations made by Miss Bancroft in Eidsvold (Upper Burnett River) and in Brisbane during 1919 and early in 1920, in connection with work carried out in collaboration with the senior author, are included. Certain data presented in this paper were briefly referred to in an article by one of us last year (Johnston 1921).

Froggatt and Froggatt (1916, p. 9) have published a statement regarding the average number of eggs found in the ovaries of various blowflies in New South Wales. The larval stages of some of the flies referred to in this paper have been described recently by Sinton (1921), while short accounts were published some years ago by Messrs. W. W. and J. L. Froggatt. The dipterous larvæ which produce myiasis in man and domesticated animals have been reviewed by Patton (1921).

Lucilia sericata Meigen.

The fly to which this name is attached in Australia is very common during summer, being prevalent in the vicinity of houses. It is frequently seen in winter in Queensland, increasing in numbers gradually until it becomes the dominant blowfly in December. It is one of the sheep maggot-flies. Froggatt (1921, p. 812) has referred to its prevalence in New South Wales.

It is almost certain that more than one species is included under this name in Australia. The bronze-coloured forms so commonly met with are not necessarily specifically distinct from the bright-green individuals, as both may be found amongst the progeny of one female. The British Museum contains specimens with this specific designation from Melbourne, as well as from India, Egypt, South Africa, Great Britain, etc. One of the New Zealand sheep blowflies is identified as belonging to this European species.

LUCILIA SERICATA.

Periods.	January.	February.	March.	April.	May to September.	October.	November.	December.
Egg (hours) ..	16–17	16–17	16–17	18	24	20–22	16–23	16–22
Larval feeding (days)	4–5	4–5	4–5	5	5–6	5	4–6	4–5
Larval resting ..	3	2–5	2–7	3	5–22	4–5	3–5	3–5
Total larval ..	7–8	6–13	6–8	8–9	12–29	9–10	8–9	8–10
Pupal ..	7	6–8	6–8	7–8	11–17	7	7	6
Egg deposition to emergence of adult	13–16	12–16	14–16	15	26–28	15	12–13	12–16
Maturation ..	6–7	6–9	6–7	6–10	8–10	8	6–8	6–8
From emergence to oviposition	8–9	8–10	8–11	8–11	12	10	8–10	8–16
Adult longevity ..	25–35	12–25	12–36	28	20–29	..	15–35	15–36

In all tables in this paper the egg period is given in hours and the remaining periods in days unless otherwise indicated.

The egg period is generally between 16 and 17 hours in summer. The larval feeding stage usually occupies from 4 to 5 days except during winter when it takes 5 or 6; while the larval resting stage is generally 3 to 4 days in summer and

7 to 10 in winter. The pupal period is usually 7 days except during winter months when it may be twice as long. The time elapsing between the deposition of the egg and the emergence of the fly is generally about 13 days during summer, 15 days in spring and autumn, but considerably longer in winter. Generally about 8 days elapse between emergence of the adult and its subsequent oviposition. Longevity in captivity is usually about 20 days. Copulation may occur whilst on the wing and last only a few seconds or it may take place while the insects are resting and is then prolonged.

Froggatt (1913, pp. 25, 29) mentioned that in New South Wales eggs hatched out within a day (six hours in December) after having been laid; that maggots were fully fed on meat in 6 or 7 days after hatching, pupating in the soil beneath; and that flies emerged on the sixth day after commencement of pupation. The period from oviposition to emergence was thus about 12 or 13 days in summer, which corresponds with our observations in Brisbane during summer. In an earlier paper (1905, p. 17) he had stated that the larval stages occupied about a fortnight.

A series of observations regarding the pupating habit of this fly was published recently by us (J. & T. 1921, pp. 114-5; 1922, p. 130).

Bishopp and Laake (1915, p. 473) as a result of observations at Dallas, Eastern Texas, reported that hatching required from less than 24 hours to 7 days; the larval period 4 to 9 days in summer, but from 3 to 4 months during late autumn and winter; the pupal period about 5 days in summer but from 24 days to 5 months in winter; the total developmental period 11 to 15 days in summer increasing to from 4 to 6 months during late autumn and winter; longevity of adults in captivity 10 to 40 days; emergence to egg-laying 4 to 21 days.

Bishopp, Mitchell, and Parman (1917) recorded that *L. sericata* appeared during the warmer days of spring and persisted through the summer in U.S.A., where it took about as long to pass through its development as did the common black wool-maggot fly, *Phormia regina* Meigen, viz. about 11 to 15 days from egg to emergence of the adult fly.

In regard to a related fly, *Lucilia cæsar*, Herms (1915) stated that the egg period was from 6 to 48 hours; the larval feeding stage 3 to 7 (generally 5) days; the larval resting or prepupal stage usually 6; the pupal 8 to 34 (commonly 12) days; the total number of days elapsing betw⸗n egg deposition and

emergence of the adult fly being from 16 to over 60 days, generally 24 days; and the average longevity of the fly about 30 days. Pierce (1921, p. 132) mentioned that the larval period averaged 14 days and the pupal about the same length, but that in warm weather in Texas the larval stage occupied 3 to 12 days and the pupal 5 to 16 days while the total development (to emergence) required 11 to 24 days. Bishopp (1915, p. 323) stated that in Eastern Texas incubation required less than 24 hours in summer but up to 7 days in winter; the larval stage 3 to 9 days; pupal 3 to 13; egg to emergence of adult 9 to 21 days during comparatively warm weather; and that oviposition occurred in from 5 to 9 days after emergence.

Patton (1922A) mentioned that in India the eggs of *Lucilia serenissima* F. incubated in from 24 to 36 hours according to temperature.

Chrysomyia albiceps Wied.

This is the adult of the larger so-called hairy maggot and is one of the worst of the sheep blowflies in New South Wales and Queensland, where it is generally known as *Pycnosoma* or *Chrysomyia rufifacies*. It is most abundant in Brisbane during January and February, while in sheep districts of Central and Western Queensland it is especially in evidence during March, April, and May and may occur in numbers even in June.

Mr. Froggatt (1921, p. 811; 1920, p. 472) has lately used the name *Chrysomyia albiceps* Wied, as being its correct name, the determination having been made by Patton, who mentioned that it was a common Indian species. The latter author (1922C) has just published an account of the fly and its larval stages.

CHRYSOMYIA ALBICEPS.

Periods.	January.	February.	March.	April.	May to September.	October.	November.	December.
Egg (hours) ..	16	16–17	16	19	21	18	18	16–17
Larval feeding (days)	4–5	4–5	4–5	5	5–6	5	5	5
Larval resting ..	2–3	1½–2	2	2–3	4–10	..	2–5	2–3
Total larval ..	6–8	5½–7	6–8	6–8	10–15	7–?	7–10	7–8
Pupal	4–8	3–5	5–8	7–8	10–20	6	4½–5	4½–5
Deposition of egg to emergence of adult	10–13	9–13	11–16	13–17	20–36	13	12–16	12–14
Longevity of adult	2–29	10–30	..	..	26	23	6–29	16–30

The larva usually feeds for about five days, then follows a resting period generally occupying from 5 to 6 days during winter and 2 days in summer. The total larval period during midsummer (January to March) is usually 6 days, but 8 days during early summer, and longer during winter. The pupal period is usually from 4½ to 5 days during the whole summer. No definite information is available as to the time which elapses between adult emergence and sexual maturity, and between emergence and oviposition, but about 5 or 6 days appear to elapse in the latter case (midsummer). Longevity in captivity during summer commonly ranged between 15 and 26 days.

Jarvis (1913, p. 11), who bred it in confinement at an average mean temperature of 75·5° F. (Longreach district, during October), stated that 7 days intervened between egg-laying and pupation—flies emerging 4 days later (i.e., a pupation period of 4 days). Hence the total period between deposition of eggs and the emergence of flies which developed from them was 11 days (Jarvis stated 12 though his dates indicate only 11).

The most rapid development from egg deposition to emergence noted by us occupied 9 to 10 days (February), 3 to 4 days of which were spent in the pupal condition (J. & T. 1921, pp. 112, 116). Illingworth (1918) referred to a similar rapid development of this fly in Hawaii (midsummer, July), where less than 4 days elapsed from the time of the deposition of the egg to the end of the larval feeding stage. He reported that the pupal condition occupied about 6 days, but this interval would include the time that we have indicated under larval resting stage, which would probably be 1 to 2 days. The total time from egg deposition to emergence was about 9½ days, just as in the case noted by us. Froggatt (1913, p. 26) stated that less than a fortnight elapsed between these periods (New South Wales).

Patton (1922c, p. 563) states that the second, but more especially the third, stage larva of *C. albiceps* is entirely predaceous, feeding on the larvæ of other Calliphorinæ, as well as those of certain species of *Musca* in Mesopotamia and India, a character which it shares with *C. villeneuvii*. J. L. Froggatt (1919, p. 259) had already mentioned that the "hairy" larvæ of *Pycnosoma rufifacies* and *P. varipes* attacked and devoured the smooth-skinned maggots of other blowflies

such as *Anestellorhina augur*, *Pollenia stygia*, and *Lucilia sericata*, while those of *Ophyra nigra* would attack all species.

Patton mentioned that the female lays her eggs amongst those of other Calliphorines; that the first instar lasts for about 36 hours, as in the case of *C. villeneuvii*, and the second from 2 to 3 days.

The biology of the related fly *Chrysomyia* (or better, *Cochliomyia*) *macellaria* Fabr., well known as the American screw-worm, which deposits its eggs in living domesticated animals as well as in man, but especially in cattle and sheep, has been worked out by various investigators. Bishopp, Mitchell, and Parman (1917) reported that eggs hatch in less than 4 hours, and when infesting living animals the larvæ are mature and drop from the wound in from 4 to 5 days, but when in carcasses they require 6 to 20 days unless the weather be hot and damp. The maggots burrow from 1 to 4 inches into the ground before pupating. The pupal stage lasts from 3 to 14 days, when the flies emerge and are soon ready (3 to 18 days) for egg-laying. The whole life-cycle is completed in from 1 to 4 weeks according to temperature and humidity. The adult fly lives only a short time—from 2 to 6 weeks. (*See also* Bishopp, 1915, p. 325-6.)

Herms (1915, p. 235) reported that the shortest period observed to elapse between the deposition of the egg or maggot to the emergence of the imago was 9 days, lengthening to 2 weeks or more under less favourable circumstances. Castellani and Chalmers (1919, p. 848) stated that the eggs hatched in from 1 to 9 hours, the larva matured in from 5 to 7 days, and the pupa in from 9 to 14 days. (*See also* Hall, 1921, p. 15.)

Chrysomyia (Microcalliphora) varipes Macquart.

This is the smaller hairy maggot-fly, commonly known as *Pycnosoma varipes*. Probably more than one species has been included in the previous accounts given under this name. Townsend in 1916 made it the type of his genus *Microcalliphora*. Though common during summer, this fly reaches its maximum development in Brisbane in February, during which month its life-cycle may be very much shortened, at times not more than 8 days elapsing between the deposition of the egg and the emergence of the resulting fly. The usual period during summer was found to be 10 or 11 days, increasing as winter approached, when over a month might be required.

MICROCALLIPHORA VARIPES.

Periods.	January.	February.	March.	April.	May to September.	October.	November.	December.
Egg (hours) ..	17	17	17–18	18	..	18	17–19	17–19
Larval feeding (days)	2¾–4½	2¾–5	4–5	4–5	5	4½–5	4½–5	4½–5
Larval resting ..	1–2	1–2	1½–2	2–3	3–8	..	1½–2	1–1½
Total larval ..	4¼–6	5–7	5½–7	6–8	8–13	..	6–7	5½–6
Pupal	2–10	3–5	4½–5	5	8–21	..	4½–5	4½
Deposition of egg to emergence of adult	9–14	8–11	10–11	11–14	17–36	12–15	10–12	10–11
Longevity of adult	19–28	26–28	26	26–28	29	23–29	20–28	28–29

The larval feeding period generally occupied 3 days in January and 4½ to 5 days for most of the year; while the larval resting period usually extended over 1 or 2 days in summer but 5 or 6 in winter. The pupal period commonly occupied 4 to 4½ days in summer.

Chrysomyia megacephala Fabr.

This large, deep-blue blowfly is more commonly known in Queensland, the East Indies, and Hawaii as *C. dux* Esch. Van der Wulp in his "Catalogue of the described Diptera from S. E. Asia" (1896, p. 148) quotes the latter name with *Lucilia flaviceps* of Macquart and of Walker as a synonym.

Froggatt has referred to it frequently and figured it as *Lucilia tasmaniensis* (Brisbane, New Hebrides, and Solomon Islands), but recently (1921, p. 812) has recorded it as *C. flaviceps* apparently on the authority of W. S. Patton, who reports it as a common "bluebottle" blowfly of Eastern bazaars and as one which breeds readily in decaying animal matter.

It appears in Brisbane in great numbers during the summer but does not become the dominant species until about March. It occurs in Sydney but is not so abundant there. The British Museum contains specimens from the Northern Territory and many North Queensland localities.

Though it is readily attracted to decomposing animal matter we have not yet observed it ovipositing nor have we bred it out from carrion.

Patton (1922B), who recognised this fly as belonging to Fabricius' species, described the larval stages and mentioned that the larvæ hatch out in about 24 hours in India. Though various stages in the related Indian blowflies, *Chrysomyia bezziana* and *C. nigriceps*, have been described by Patton (Ind. Jour. Med. Res. 8 (1), 1920, pp. 17-29 ; 1922B), the times occupied by them are not mentioned.

Neopollenia stygia F.

The golden-haired blowfly, known also as *Calliphora villosa*, occurs very commonly during the winter months in Western Queensland. It becomes less abundant in September and diminishes in numbers as summer approaches, when it is seldom seen. Froggatt reports it as being prevalent in New South Wales sheep-country from September onwards well into the summer. He states that it is common throughout the year in Sydney.

We have not kept records of the developmental periods of this fly. Froggatt (1915, p. 20) states that the time required for the egg to develop into a fly in summer in New South Wales averages a fortnight.

Paracalliphora augur L.

This blowfly is known under a variety of names—*Calliphora oceaniæ*, *C. augur*, *Anestellorhina augur*, etc. The genus *Paracalliphora* was erected for it by Townsend (Canad. Entom. 48, 1916, p. 151).

The fly is quite common in Brisbane during the winter (May onwards), increasing as *N. stygia* begins to diminish, but it is not abundant in summer. It is capable of depositing either eggs or maggots and at times both may be deposited on the same occasion. Eggs usually hatch out in about six hours in Brisbane. The larval feeding period is about 4 days, while the resting stage occupies about 5 days except during winter when it is usually 6.

PARACALLIPHORA AUGUR.

Periods.	January.	February.	March.	April.	May to September.	October.	November.	December.
Larval feeding ..	4	..	..	..	5	4	4	4
Larval resting ..	..	..	..	..	5–8	4–6	5	4–5
Total larval ..	..	..	..	..	10–14	8–9	9	8–9
Pupal	..	..	..	10–14	10–19	13–14	13	13
Egg deposition to adult emergence	..	20	..	..	21–33	21	19–20	20

Froggatt (1915, p. 19) reported breeding the species from carrion all the year round though it was during winter that it infested sheep. He recorded that during winter the larvæ required 2 to 3 weeks to become fully fed while the pupal stage occupied a month to 6 weeks, so that from 6 weeks to 2 months were required under laboratory conditions, but that a fortnight or even a month longer was necessary under natural conditions. During summer, he stated, only 14 days intervene between the egg and the emergence of the adult fly, larvæ being fully fed on the seventh day.

In an earlier paper (1913A, p. 23) he mentioned that eggs laid in November gave rise to larvæ which pupated in 6 days and emerged 11 days later, the period from the egg to emergence of the fly being 14 to 15 days (his dates show a period of 17 days). During December, 18 days elapsed in a case recorded.

Calliphora erythrocephala Meigen.

This large, dark blowfly, an importation from Europe, is common in New Zealand and in Sydney. As we have seen only one specimen in Brisbane it must be very rare, though it may succeed in establishing itself. No data regarding its biology in Australia have been published.

Bishopp (1915, p. 327) mentioned that in Eastern Texas the incubation period was 24 hours; the larval feeding stage 3 or 4 days; the pupal stage 7 to 9 days; the period from

egg deposition to emergence ranged from 15 to 20 days; and that oviposition occurred in from 12 to 17 days after emergence.

Pierce (1921, p. 131) stated that the eggs required 10 to 24 hours to hatch; the larva $7\frac{1}{2}$ to 8 days at 23° C. (73·5° Fahr.); and the pupa 14 days for development, though larvæ had been known to attain full development in from 3 to 4 days and the flies to emerge in from 15 to 20 days after the eggs had been deposited. (*See also* Hewitt, 1914.)

Sarcophaga spp.

Flesh-flies are to be met with in Brisbane throughout the year but are particularly plentiful during March and April. They are larviparous. The larval feeding stage occupies about 4 or 5 days during summer. The pupal stage is greatly prolonged during winter, some of our specimens taking from 8 to 16 weeks before emerging. Overwintering evidently takes place in the pupal condition. From 12 to 18 days elapse during summer between larviposition and the emergence of the adult. In 2 or 3 days after emergence copulation occurs.

Herms (1915, p. 238) states that under optimum conditions, presumably at Berkeley, California, *Sarcophaga sarraceniæ* Riley requires 5 days for its larval development and 13 for the pupal, a total of 18 days from larviposition to emergence.

Sarcophaga peregrina R. D.

Period (days).	Nov.–Dec.	Jan.–Feb.	March–April.	Winter.
Larval feeding	3–6	3–5	5–6	..
Larval resting	3	3	2–3	..
Total larval	6–9	6–8	7–9	..
Pupal	8	8–9	3 to 9 weeks	8 to16 weeks
Larviposition to emergence	14–17	14–17	20 days to 10 weeks	..
Emergence to copulation	2–3	2–3	2–6	2–8
Emergence to larviposition	11	11	11	12
Larviposition to larviposition	25–28	25–28	31 days to 11 weeks	..

Sarcophaga tryoni J. & T.

During the winter this large golden fly takes 7 days to pass through its larval feeding stage, 7 to 8 days for the larval resting or prepupal stage, and 7 weeks to complete its pupal stage.

Sarcophaga impatiens Walker.

Period (days).	Jan.–Feb.	Winter.	October.
Larval feeding	5–6	7	4
Larval resting	2–3	7–8	7–8
Total larval	7–9	14–15	11–12
Pupal	5–9	19 days to 10 weeks	5–6
Larviposition to emergence ..	12–18	33 days to 12 weeks	16–18
Emergence to copulation ..	2–3	2–3	2–3
Emergence to larviposition ..	11	10–12	11
Larviposition to larviposition ..	23–30	30 days to 14 weeks	28 ?

Sarcophaga omikron J. & T.

The pupal stage (bred from decaying potato) in the Upper Burnett district during January 1920 was about 13 days (*M. J. Bancroft*).

Ophyra nigra Wied.

This shining black Anthomyid blowfly is extremely common in Southern Queensland and in New South Wales, and is readily attracted to carrion, where it may be collected all the year round.

In Brisbane the eggs usually require 24 to 25 hours for hatching. The larva feeds for 5 or 6 days and then passes through a resting stage varying in length from 7 to 11 days in summer and from 3 to 4 weeks during winter. The pupal stage lasts for about 8 days in summer and 2 to 3 weeks in winter. The period elapsing between the deposition of the egg and the emergence of the resulting fly is about 20 days in midsummer, increasing to about 30 in autumn and spring, while during winter about 10 weeks are required. In about 5 days after emergence, copulation occurs, egg-laying taking place within 1 or 2 days. The fly lives for about a month in captivity.

OPHYRA NIGRA.

Periods.	January.	February.	March.	April.	May to September.	October.	November.	December.
Egg	24	24	24–27	25	27	..	25	25
Larval feeding ..	5–6	5–6	5–6	5–6	6–7	..	5½–6	5–6
Larval resting ..	10–11	10–11	7–8	15–25	20–30	11	9–11	6–7
Total larval ..	15–16	15–16	12–15	20–30	26–30	..	15	12–13
Pupal	8	8	8–9	9–12	13–25	8	6–8	7–8
Egg deposition to adult emergence	19–24	19–24	21–30	28–29	about 10 wks.	28	21	19
Maturation ..	4½–5	4½	5	5	..	..	5	5
Emergence to oviposition	5–6	5–7	6–7	6–7	..	..	6	5
Adult longevity ..	22–29	20–28	..	..	29	28	22–29	20–29

Stomoyxs calcitrans L.

We have not attempted to ascertain the length of the various stages in the life-cycle of the stable-fly. The time which elapsed between the deposition of eggs and the emergence of the adult fly from them in Brisbane was found to be from 14 to 19 days during January and February, 20 to 33 during April, 24 to 40 during winter (May to October), 20 to 21 during November and December. The usual time in S. E. Queensland seems to be about 20 days during summer, though less in midsummer, increasing to from 3 to 5 weeks during winter. Hill's data (1918) show that a total of 21 days elapsed in Melbourne during January and February.

Bishopp (1913, 1916, 1920) has investigated the biology of *S. calcitrans* in Dallas, Texas, U.S.A. During late autumn (Sept. and Oct. 1912) he found that the egg period ranged from 1 to 4 days; larval from 11 to over 30; pupal 6 to 20; the time elapsing from oviposition to emergence being from 19 to over 42 days (1913, p. 121-2). In a later paper (1916), he gave a more complete account and stated (p. 17) that on the average the last-named period generally ranged from 21 to 25 days when conditions were very favourable; that the longest period observed for complete development was 43 days, though

it was certain that during late autumn and winter a much longer period (up to 3 months) was necessary in Northern Texas. Flies were found to live about 17 days (occasionally 29 days) in confinement when supplied with blood as food. Similar information was republished by him in 1920.

Herms (1915) reported that in the vicinity of San Francisco, California, at a temperature of 21° to 26° C. (70° to 80° Fahr.), the following periods were observed :—Egg stage 2 to 5 days, average 3 days ; larval stage 14 to 26, usually 15 days ; pupal stage 6 to 26, generally 10 days ; time elapsing from oviposition to emergence 22 to 57 days, average 28 days. Copulation was found to occur within a week from emergence and egg deposition about 18 days after emergence, at the temperatures stated. The longevity of adults averaged 20 days, the maximum observed being 69 days.

Hewitt (1914, p. 200) reported that (in England, presumably) the egg required from 24 hours to 4 days to hatch ; the larva 7 to 30 days for its development ; and the pupa 5 to 20 days before emergence. The period from egg deposition to the emergence of adults varied from 13 days to 10 weeks. Flies were found to live from 72 to 94 days in captivity and to begin to oviposit on the 9th day after leaving the puparium.

Newstead (1906) found that in England, at a day temperature of 72° Fahr. and a night temperature of 65° Fahr., eggs hatched in 2 to 3 days [1] ; the larval stages occupied 14 to 21 days (or even as much as 78 days when conditions were unfavourable) ; the pupa 9 to 13 days ; while the period from egg deposition to emergence required from 25 to 37 days, but when conditions were drier and the larval stage as a consequence was lengthened, then the cycle occupied from 42 to 78 days. Howard (1912) and Hindle (1914) republished Newstead's figures. (*See also* Newstead, Dutton, and Todd, 1907, pp. 75-86.)

Mitzmain (1913), working in the Philippines at a warm temperature of 30-31° C. (86°-91° Fahr.), found that the larval life averaged 12 days, the pupal 5 days, while the maximum period for which flies lived in captivity was found to be 72 days in the case of a female and 94 for a male.

[1] Newstead (in Newstead, Dutton, and Todd, 1907, p. 87) states that at a temperature of 64-67° F. eggs did not hatch until the 8th day.

Patton and Cragg (1913, p. 366) reported that in India the egg hatched in 12 hours, the larva matured in from 7 to 21 days, and the pupa in about 4 days. Hence the total period from egg deposition to emergence occupied from about 11 to 25 days.

Lyperosia exigua Meijere.

The bionomics of the buffalo-fly (a relative of *Stomoxys*), in the Northern Territory, were briefly dealt with by Hill (1916). The egg stage occupied 18 to 20 hours; larval, i.e. from the hatching of the egg to the formation of the puparium, 72 to 96 hours; pupal stage 72 to 120 hours. The life-cycle (egg to emergence) was found under laboratory conditions, in the case of flies reared in March (late summer) to average 169 hours (7 days), ranging from 120 hours during warm sultry weather and 192 to 195 when the weather was rather cooler; while in the case of a fly reared in June when the weather was still cooler, 208 hours (nearly 9 days) elapsed. Patton and Cragg (1913, p. 376) state that in India the fly emerges in from 5 to 8 days from the time the eggs are deposited.

The biology of *Lyperosia* (or *Hæmatobia*) *irritans* L. in Europe has been studied by Wilhelmi (1921). Pierce (1921, p. 234) states that in U.S.A. this species, the hornfly, requires about 17 days from egg to adult.

Musca domestica L.

With the exception of a casual record by Johnston and Bancroft (1920), the only work published relating to the biology of the common housefly in Australia is that of Willis (1913), though Cleland (1913) has given information regarding the percentage of this species amongst the flies caught in houses in Sydney. Froggatt (1910, p. 246) referred to the stages of housefly development, but there is nothing to indicate that his periods relate to actual observations in Australia.

Except in a few cases, no attempt was made by us to determine the length of time passed by the fly in its various developmental stages. It was ascertained that in Eidsvold during November the egg required a day to hatch; the first instar was passed through in a day; the second in a similar period; the third in 3 or 4 days (making a total egg and larval period of 6 to 7 days); the pupal stage in 9 to 10 days; making a total of from 15 to 17 days from oviposition to emergence (Johnston and Bancroft, 1920, p. 5).

During November 1919 in Brisbane the combined egg and larval stages required from 5 to 7 days (generally 6), and the pupa from 8 to 10 (generally 9) days for development, so that the total period from egg deposition to adult emergence was from 14 to 16 days. This month was dry. During the succeeding January and February (1920) the periods were—Egg plus larval, 4 to 6 days; pupal, 4 to 8; the period between oviposition and emergence ranging from 8 to 12 days during these hot, moist months.

From later observations made by us in Brisbane (1920, 1921), it was ascertained that the housefly could pass through its stages from the egg to the imago in from 7 to 8 days during midsummer, but needed from 11 to 15 during autumn (April and May), and 12 to 16 during winter. Horse-manure was used as the pabulum in all our breeding work with houseflies. Copulation took place in from 4 to 8 days after emergence and oviposition occurred 4 days later.

Willis (1913), working in Sydney during November and December 1910, gave his minimal observation in the case of material incubated at 28-30° C. (82-86° F.), when a period of 12 days elapsed between the date when eggs were first seen and adults first emerged, while with a temperature maintained at 30-34° C. (86°-93° F.) it was not quite 10 days. He noted that pairing seemed to occur two days after emergence, and reported that oviposition took place six days after emergence, at the higher temperatures mentioned.

Hill (1918) reported that in Melbourne eggs hatched in from 12 to 24 hours, flies emerging during midsummer in about 14 days after eggs had been laid. Such flies mated in from 4 to 6 days after emergence and oviposition occurred about 4 days later. Midsummer in the Southern States of Australia is comparatively dry whereas in Brisbane it is normally moist (January to March).

Patton and Cragg (1913) reported that, in India, houseflies emerged about the 6th or 7th day after the eggs were laid; while Smith (1907) recorded that a period of 8 days elapsed when flies were bred from horse-manure at Benares, India. These abbreviated periods are comparable with those above recorded by us as observed during the moist midsummer of S. E. Queensland.

Hewitt (1914, p. 109) reported that the shortest periods

observed by him during the summer in Manchester were—Egg, 8 hours; first instar 24 hours, second 24 hours, third 3 days; pupa 3 days; total 8 days 4 hours,—but that probably not less than 9 days, and commonly 10 or more, elapsed under natural conditions. It should be mentioned, however, that Griffith (1908) obtained a minimum of 8 days (egg to pupa $4\frac{1}{2}$ to 6 days, pupa to fly $3\frac{1}{2}$ days) in the south of England. The minimum obtained by Newstead (1907) in Liverpool was 10 days, as also was that recorded by Packard, observed in Massachusetts, U.S.A. At an average daily temperature of 22·5° C. in England, flies require 14 to 20 days to emerge when eggs were laid and the larvæ developed in horse-manure (Hewitt).

The influence of moisture and temperature on the length of the various periods in fly development has been studied by Newstead (1907) and by Hewitt (1914). (*See also* Graham Smith, 1914, p. 42.) Egg period at 10° C. 2 to 3 days; at 15-20° C. about 24 hours; at 25-35° C. 8 to 12 hours. Larval period—first instar 20 to 36 hours or even to 4 days; second instar 24 hours (25-30° C.) to several days; third instar (including prepupal stage) 3 to 4 days (25-35° C.) ranging to 8 or 9 when conditions less suitable; total larval period 5 to 8 days (when conditions of temperature and fermentation favourable) ranging to 8 weeks. Pupal period between 3 and 4 days (at 35° C.) ranging to several weeks. The temperatures mentioned (25-35° C.) approximately correspond with those in tropical climates and in subtropical regions (such as Brisbane) during midsummer, and the results obtained by Hewitt, using incubators, are similar to those recorded by Patton and Cragg and by Smith for Indian conditions, and by us for Eastern Queensland.

Howard and Hutchison (1915, 1917) gave the larval period (including egg stage) as 4 to 5 days under favourable conditions in U.S.A.; pupal 3 to 10 days in midsummer (up to 5 months during midwinter); and mentioned that the shortest time recorded as elapsing between egg deposition and adult emergence in U.S.A. was 8 days, records of 10 to 12 days being common; and that only 3 or 4 days were needed during midsummer for females to reach maturity after emergence.

This preoviposition period, as it has been named, has been carefully studied by Hutchison (1916), who attempted to represent graphically its relation to temperature. The time

varied from $2\frac{1}{2}$ to 23 days, from 3 to 5 days being required when the temperature was in the vicinity of 80° F. (which corresponds with Brisbane summer).

Howard (1912) reported that in Washington D.C., during midsummer, larval life occupied 5 days (24 hours + 24 hours + 72 hours) and the pupal normally 5 days; while Pierce (1921, p. 129) gave them as 4 and 3 to 10 respectively (U.S.A.).

Herms (1915) published maximum and minimum periods for egg, larval, and pupal stages as well as for total periods from egg to imago, based on observations in Berkeley, California. In regard to the last-named period he found it to vary from 12 to 18 days, usually from 14 to 18, but at a temperature maintained at 30° C. the minimum observed was $9\frac{1}{3}$ days. The average, minimum, and maximum lengths of time in days required between egg deposition and emergence at certain temperatures were found to be respectively as follows:—At 16° C.—44·8, 40·5, 48·6; at 18° C.—26·7, 23·1, 30·25; at 20° C.—20·5, 18·8, 22·25; at 25° C.—16·1, 14·5, 17·8; at 30° C.—10·4, 9·3, 11·5.

Stiles (1921) stated that larvæ matured in the shortest time in fermenting materials at a temperature of 90-98° F. (32·2°-36·7° C.) and that at higher temperatures (100-110° F.) they left the hotter portion of the manure in which they were feeding. At temperatures between 65° and 75° F. (18·3-23·9°C.) the "duration of life-round" was 3 weeks, presumably in the vicinity of Washington D.C.

Hewitt (1914) reported that flies reached sexual maturity in England in August and September in from 10 to 14 days after emergence, oviposition occurring 4 days later. Hutchison (1916) stated that copulation may occur on the first day after emergence, but usually took place between the 3rd and 6th days, provided the temperature was not below 55° F.

Austen (1920, p. 19) reported that, in June 1915 at Rouen during very hot weather, houseflies bred out in a little more than 6 days from eggs laid in horse-manure, while at Kantara, Suez Canal, in May 1916 during extremely hot weather, about $7\frac{1}{2}$ days elapsed, but that in England under very favourable circumstances 7 to 8 days were needed. To the latter period there must be added from 14 to 18 days before the emerging flies can lay eggs; hence in the British Isles during very hot weather about 3 weeks would be sufficient to elapse between

egg deposition by a fly and oviposition by the progeny of such fly (p. 16). Howard and Hutchison (1915, 1917) showed that in Washington D.C. such would be possible in from 11 to 14 days during midsummer. We do not know the minimum preoviposition period in Brisbane, but, as our climatic conditions during summer are somewhat similar to those in which Hutchison obtained his minimum results, it is likely that in the coastal districts of Queensland during midsummer (say January to March) a period of from 9 to 11 days may represent the minimum period between egg deposition by a fly and by its progeny.

We have no information regarding the length of time houseflies can live in captivity in Australia, but Austen (1920) mentioned 7 to 16 weeks in England; while Howard and Hutchison (1915) recorded periods of 30 days during winter (New Orleans), 35 to 40 days at temperatures of 65-75° F. (Virginia), one of 70 days at a temperature ranging from 32° to 50° F. (Virginia), and (1917) one of 91 days (44-57° F.). Hutchison (1916) recorded a longevity varying from 1 to 54 days (average of 3,000 records being 19+ days) during summer and autumn (U.S.A.). On account of the much warmer climate of Australia, such long life-periods are unlikely to occur here normally.

Bishopp, Dove, and Parman (1915), working at Dallas and Uvalde, Texas, found that eggs hatched in less than 24 hours even in winter; the larval stages required from 3½ days to about 3 weeks, usually 4 to 7 days during warm weather; pupal stage 3 to 26 days, ranging to more than 2 months during winter; time from egg to emergence 8 to 11 days (midsummer) increasing to 25 to 51 (midwinter); and in one case the combined larval and pupal stages occupied 6 months (November to May). Copulation was observed to occur from 1 to 16 days after emergence. Oviposition took place in from 4 to 20 days after emergence—usually 4 to 9 days in summer and 10 or more in autumn. Longevity in captivity was found to be from 2 to 53 days—generally 2 to 4 weeks during summer when food was sufficient.

Musca vetustissima Walker.

This is the common, small, dark, bush fly of Australia and has been referred to in literature under a variety of names. Coquillet determined it for Froggatt (1905) as *Musca corvina* Fabr. (a European fly now known as *M. autumnalis* Geer.),

and it is under such name that the latter author has figured it and written of it in his various papers excepting in a recent article (1921) where he calls it *Eumusca australis*, though it has been shown that the latter specific name belongs to a quite distinct fly (Johnston and Bancroft 1920A, 1920C). It has also been referred to as *Eumusca vetustissima*, as it falls within Townsend's genus if the latter is recognised as valid (Johnston and Bancroft 1920C, Johnston 1921B).

Bezzi determined it for G. F. Hill as *Musca humilis* Wied., an Indian fly, and it is under this name that Hill mentioned it recently (1921). Dr. Patton, in a letter to the senior author dated August 1921, stated that Walker's species was a synonym of Wiedemann's, but in a letter a few months later (Dec. 1921) he said that *M. vetustissima* was certainly not *M. humilis*, but was Macquart's *M. pumila*. Our bush fly is certainly very much like the figure of *M. humilis* given by Patton in Indian Journal of Medical Research, 7, (4), plate 68[2] (For further references to *M. humilis see* Patton, l.c. 8 (1), 1920, pp. 1-16; Rev. Appl. Ent. B. 9 (6), p. 102.) In view of the above contradictory statements we prefer to retain Walker's name until some authoritative pronouncement shall have been made.

The biology of the fly under the climatic conditions occurring in Brisbane and in Eidsvold (Upper Burnett River district) has been made known by Johnston and Bancroft. The time passed in the egg stage and in the various instars and pupa has been ascertained, the egg and larval stages usually requiring 4 to 5 days and the pupal about 6 in summer, whereas in spring and winter the latter may need 7 to 9 days. The total period from egg to imago was found to be from 10 to 14 days in Eidsvold during November when the weather was rather dry. (Johnston and Bancroft 1920A; 1920C, pp. 35, 41; Johnston 1921B.)

Other observations during October, November, and December confirm the above results, the egg hatching out in less than 24 hours; the combined egg-plus-larval period being from 4 to 6 days, generally 5; the pupal period 6 to 10, usually 6 or 7 days; the total period from egg deposition to emergence being 11 to 13 days. No doubt all stages would

[2] The life history and breeding habits of *M. determinata* and *M. humilis* are described in the paper, pages 754-5, 757-8.

be abbreviated during the moister summer months (January to March or April), but we have no records for that part of the year.

Awati (1920), in dealing with the biology of certain Indian species of *Musca*, stated that *M. promiscua* (a species with thoracic stripes somewhat like those of *M. vetustissima*) passed through its stages from the egg to the sexually mature imago in 9 to 10 days (egg less than one day; larva 1; pupa 4; adult 4 days before maturity was reached), eggs being laid from 4 to 10 days after copulation. The time elapsing between egg deposition by a fly and by its progeny from such eggs (i.e. from egg stage to egg stage) was found to be from 19 to 28 days. The longevity varied from 42 to 56 in the different species of *Musca* under observation.

Musca fergusoni Johnston and Bancroft.

This is much more robust than the last-mentioned species and has four well-defined thoracic stripes. It has received several names. Macquart described it as *M. australis*, but the name was already preoccupied by Boisduval. Hill (1921) quoted these names as synonyms of *M. lusoria* Wied., an Indian fly, the determination having been made by Bezzi. Johnston and Bancroft transferred the species to *Viviparomusca* Townsend (Johnston and Bancroft 1920c; Johnston 1921b).

Dr. Patton in a letter dated August 1921 stated that the species belonged to the *lusoria-bezzii* group, but in a later note (Dec. 1921) informed us that it was *M. convexifrons* Thomson (*nec* Bezzi). Its similarity to *M. bezzi* Patton and Cragg was pointed out in the original account (J. and B. 1920a). Until the synonymy is definitely established we think it preferable to use the above name.

The various stages in the life-cycle and the periods of time occupied have been dealt with (J. and B. 1920a; Johnston 1921b). The fly is practically larviparous, as a larva in the second instar escapes from the thin eggshell immediately the egg is deposited by the female. Pupation occurs on the 3rd day, the larval stages requiring 2 or a little over 2 days during summer, but 4 in October and up to 6 in winter. The pupal stage required from 9 to 15 days in summer and 27 to 32 days in winter (Eidsvold).

The fly has been found breeding throughout the year in

the Brisbane district, but generally only a few pupæ of the species can be collected even from considerable quantities of cow-manure during winter. The pupæ are to be found in the manure close to the surface. The species occurred most commonly during March and April.

Additional observations during 1919 and 1920 regarding the life-cycle may be mentioned—(*a*) days in larval stage, (*b*) length of pupal stage, (*c*) total time elapsing between larviposition and emergence :—

——	(*a*) Larva.	(*b*) Pupa.	(*c*) Total.
January	2	7–8	9–10
February	2	7–8	9–10
March	2–3	7–12	9–14
April	3– ?	13–15	16–18
May	5–6	?–26–32	19–38
June	7–8	26– ?	33–40
July to September	7–8	27–39	34– ? 47
October	4	11–12	15–16
November	3	8–9	10–12
December	2–3	8	10–11

The total cycle in Brisbane apparently requires about 10 days for its completion during summer, and over a month during winter. The pupal stage occupies about 8 days during summer but about 4 weeks during winter, though our longest record was 39 days. There is a marked lengthening of the larval period during winter months. Flies kept in captivity during winter lived for periods varying from 10 to 31 days, usually about 24 days.

Musca terræ-reginæ Jnstn. and Bancroft.

The biology of this rather uncommon fly has been studied by Johnston and Bancroft (1920A, pp. 34, 35; Johnston, 1921B), whose observations were made chiefly at Eidsvold, Upper Burnett River, the results obtained being practically the same as those ascertained in the case of *Musca domestica* when

under similar conditions (egg less than 24 hours; first instar 24 hours, second 24 to 48 hours, third 2 to 3 days, total larval 5 to 7 days; pupal 7 to 10 days; total from egg to emergence 12 to 17—while the total in the case of the housefly during the same month, November, was from 15 to 17 days).

Additional data :—

——	Larval.	Pupal.	Egg to Emergence.
November	5–9	7–11	13–18
December	5–7	5–8	10–14
January	4–5	6	10–11

Musca hilli Jnstn. and Bancroft.

This is also a rather uncommon fly. Observations regarding its biology have been made by Johnston and Bancroft (1920A, p. 38; Johnston 1921B), working at Eidsvold and in Brisbane during midsummer, the periods being found to be similar to those of the housefly under similar conditions (larva 5 to 6 days; pupa 6 to 9; total 11 to 15 days). In another paper (J. and B. 1920B, p. 74) they refer to a total period of from 8 to 10 days from egg to emergence in Brisbane during midsummer.

Observations show that the larval period in Brisbane during midsummer ranges from 4 to 6 days (generally 5 or 6); the pupal 5 to 8 (usually 6 days); and the total period between egg deposition and emergence from 10 to 14 (usually 11 to 12) days.

Hill (1921) refers to this species as a synonym of *M. nebulo* F., a common Indian fly, his information having been derived from Prof. Bezzi. Major Patton in a letter (August 1921) to the senior author stated that *M. hilli* was *M. ventrosa* Wied., but in a later letter he reserved judgment. But Hill (1921) recorded certain specimens from North Queensland as *M. ventrosa* Wied. (syn. *M. nigrithorax* Stein)—Bezzi's determinations,—but this refers to a different fly. We prefer to retain the above name until the synonymy shall have been settled.

Awati (1920) did not fix *M. nebulo* on account of its scanty original description, and in dealing with the biology of one of the Indian flies with a four-striped thorax, *M. divaricata,* he added (? *nebulo*). In regard to this fly he stated that the egg required about a day, the larva a day, and the pupa 4 to 6 days—thus 6 to 8 days from egg to emergence; while 4 to 8 days were required for maturity, giving a total of 10 to 16 days. Egg-laying occurred 4 to 10 days afterwards, the period elapsing between the time of oviposition of a fly and that of its offspring arising from such oviposition (i.e. from egg to egg) being from 19 to 28 days.

Pyrellia proerna Walker.

This handsome greenish-blue fly, which in Brisbane so commonly frequents cowdung for food and for the purpose of oviposition, has been referred to in earlier papers by Johnston and Bancroft as *Lasiopyrellia* sp. (1920A, p. 182) and *Pseudopyrellia* sp. (1920B, p. 74; 1029C, p. 42). The species occurs in North Queensland also. The flies commonly become a deep blue after having been dead a few days.

Specimens taken by the senior author to the National Museum, Washington D.C., and to the British Museum, were determined by Dr. Aldrich as *Pseudorthellia viridiceps* Macq. and by Major Austen as *Pyrellia proerna* Walker, respectively. The material was compared by Austen with Walker's type (a female—locality unknown) in the British Museum, and as Walker's name *Musca proerna* (List Dipt. Brit. Mus. 4, 1849, p. 888) has a slight priority over Macquart's *Lucilia viridiceps* (Dipt. Exot. Suppl. 4, 1850, p. 249) Walker's name is here used. Townsend made Macquart's species the type of his genus *Pseudorthellia,* hence if this prove to be valid the correct name will be *Pseudorthellia proerna* (Walker). Dr. Aldrich stated that *Pyrellia viridifrons* Macq. was probably a synonym.

Though we collected all the stages of this fly, we did not keep records of the periods beyond noting that during May and June the pupal condition lasted for 18 days.

Johnston and Bancroft (1920B, p. 74) have shown that under experimental conditions the fly readily breeds in horse-dung and can become an intermediate host of the two nematodes, *Habronema musca* and *H. megastoma.*

ADDENDUM.

While this paper was in the press, three recent papers by W. S. Patton relating to the subject have reached Australia :—(1) "Notes on the Species of the Genus *Musca*" (Bull. Ent. Res., 12 (4), 1922, pp. 411-426); (2) "Some Notes on Indian Calliphorinæ, No. 6" (Ind Jour. Med. Res., 9, 1922, pp. 635-653) ; (3) "Somes' Notes on Indian Calliphorinæ, No. 7." (l.c., pp. 654-657).

In the first paper there are changes in the names of the Indian flies referred to in our paper. *M. determinata* Wlk. is a synonym of *M. nebulo*; *M. determinata* Awati is *M. domestica* (atypical); while *M promiscua* Awati is *M. humilis* Wied. The following information is given relating to Australian species :—*M. vetustissima* Wlk., *M. minor* Mcq., and *M. humilis* Stein (nec. Wied.) are quoted as synonyms of *M. pumila* Mcq.; *M. fergusoni* J. & B. as a synonym of *M. convexifrons* Thomson: while *M. hilli* J. & B. is probably identical with *M. ventrosa* Wied.

In the second paper information is published regarding the adults and larvæ of various blowflies, including *Chrysomyia albiceps* and *C. megacephala*.

In the third paper data are published regarding the biology of another Indian blowfly *C. bezziana*, and reference is made to various Australian sheep-maggot flies, more particularly to the predaceous habits of the third laval stage of *C. albiceps*.

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Some Geological Features of Northern Australia.

By Dr. H. I. Jensen.

(Read before The Royal Society of Queensland, 31st May, 1922).

INTRODUCTORY.

Geological investigation has afforded abundant evidence that Eastern Australia differs markedly from Central and Western Australia in structural characters. Thus two of the distinctive features of the east coast as compared with the centre west are the persistence of folding right up into the Tertiary period, and the abundance of alkaline lavas in the former geological province.*

Suess,† following Clarke, calls the mountain range along the east coast the Australian Cordillera, and regards it as homogeneous. The distinctions between the range country of the Cordillera and the inland regions are obvious and undisputed. It is, however, very doubtful if the homogeneity of the Cordillera extends any further north than the Tropic of Capricorn. Indeed, geological unity seems to cease at Springsure and Yeppoon at the north end, and at Cape Howe at the south end.

The South-Eastern Massif.—Tasmania, Victoria, and the Monaro district of New South Wales constitute a geological unit, characterised by intense folding movements in the Palæozoic period, and by continued elevation and absence of

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* "The Alkaline Rocks of Eastern Australia," H. I. Jensen, Proc Linn. Soc. of N.S.W., 1908.

† "Das Antlitz der Erde," Suess.

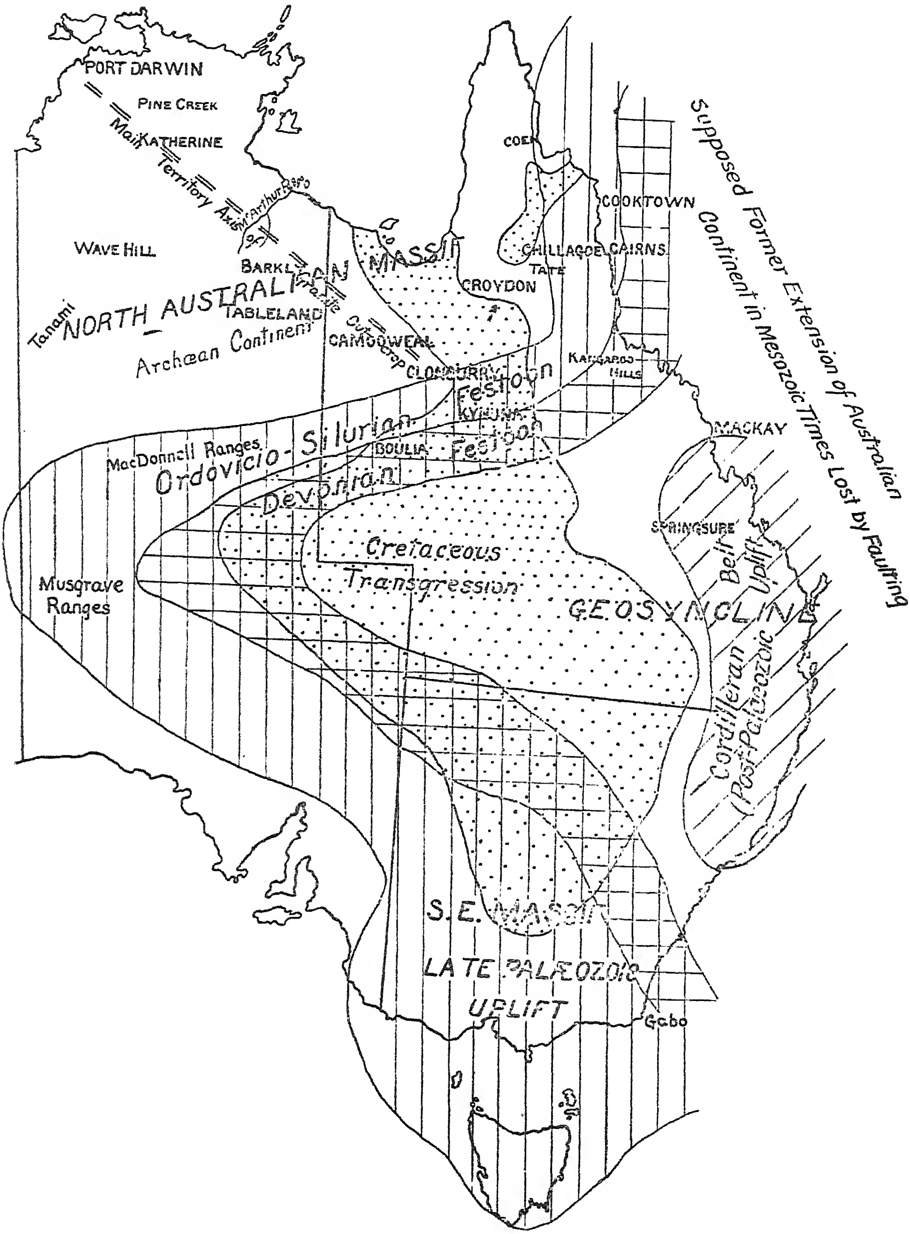

Fig. 1.—Map showing the Building of Eastern Australia.

folding since the Triassic, from which period on, plateau movement, combined with faulting and Senkungfeld formation, has been the dominant force.

The Cordillera.—The rest of Eastern New South Wales and Eastern Queensland to the Tropic of Capricorn form a geological unit characterised by a protraction of fold movements into later geological periods. In the northern portion of this unit even Tertiary beds are folded. The Triassic and Jurassic rocks are strongly folded in the Ipswich and Bundamba Coal Measures, and the Upper Cretaceous in the Styx basin. The area was also intruded by mixed lavas, of which the alkaline form an important portion, in the Tertiary period.

North Queensland is a region which is composed of a north-western massif (the Queensland portion of which might be styled the Carpentaria massif) and festoons of later formations folded upon that massif. In the Carpentaria massif fold movements ceased in early Palæozoic times, as was the case in the Northern Territory and Central West Australia, which are but an extension of the same massif. Even Cambrian rocks in the Northern Territory are but slightly folded. The eastern fringe of Carpentaria massif extends from Cape York and Princess Charlotte Bay south and south-west to Georgetown, thence south-west to Cloncurry and Camooweal. The massif is surrounded by a zone in which the Silurian and Devonian rocks are folded, but wherein the Carboniferous rocks are untouched by compressional forces. Outside this zone we have a festoon in which folding movements were protracted into the Carboniferous periods. The folded Silurian zone with sub-horizontal Carboniferous and Permo-Carboniferous outliers extends from the Cooktown mineral field through the Chillagoe field to the Charters Towers field, and thence under the Cretaceous (at Hughenden) to the district south of Cloncurry (Kynuna-Selwyn), and thence to the McDonnell Ranges in the Northern Territory. The folded Devonian belt extends from Maytown south-south-east to Mareeba; and thence as the Burdekin Series, forming the next festoon it extends west-south-west from Kangaroo Hills towards Boulia, but is largely hidden by the Cretaceous. It recurs in the Arltunga area of Central Australia. Thus the north-central massif is surrounded by successive festoons in which folding was protracted into later and later periods, which extended the area of continental movement (plateau

movement) in a south-east direction.* A similar feature is noticeable in the southern portion of the Cordilleran belt, where the area of plateau movement was extended from the south-eastern massif north to embrace the South Coast and Sydney districts prior to the deposition of the Hawkesbury sandstones.

The true geosynclinal portion of the Cordillera extends, therefore, roughly from Port Stevens to Mackay.

The true north-western massif (omitting the post-Cambrian additions), including the Territory and West Australian portions, has been an area of vertical movements only since the Cambrian period. Consequently the fissures formed by Archæozoic fracturing, which often constitute important ore channels, are of large size and great continuity, and have not been cut up, pinched out, partly obliterated and squeezed into discontinuous lenses, as has been the case in the regions which have undergone great Carboniferous and Mesozoic earth-fold movements. Thus, as far as Queensland is concerned, the continuity of lode formations and the value of our ore deposits increases from the Dawes Range northwards.

Alternation of uplift and depression, the repetition of plateau uplifts, may also have caused several zones of enrichment in the lodes of the massif areas. It would not be surprising here to find a second carbonate and oxide zone below the sulphide zone (which is not necessarily primary in all cases) in many lodes which have now been abandoned. Such a zone was found at a depth of 500 feet in the Girofla Mine, Mungana.

General mining experience has proved that the auriferous reefs of the East Australian Cordilleran region are principally quartz lodes locally enriched where they intersect carbonaceous beds, hornblende-andesites, or other rocks which favour gold deposition from magmatic solution.

In the northern massif, however, the lodes comprise both large fissures infilled with quartz, pyrites and sulphide ore, and large shear zones consisting of a ferruginous matrix carrying pay ores, and passing into sulphides below water level. An abundance of graphite is a feature of these great shear zones. In the sulphide levels graphite and pyrites are constant associates, and bear a definite relation to one another.

* Details of this zoning are given in a Queensland Geological Survey Bulletin prepared by the writer in 1919 but not yet published.

Quartz is of two ages—an older blue quartz and a later white quartz—as McLaren has shown for West Australia, in his work on "Gold," and the blue quartz which is sheared, is generally the richer. This blue quartz usually occurs in basic rocks and may be platiniferous.

McLaren's magnetite-hematite-quartz rocks, considered by him as derived from ferruginous sediments, occur abundantly in the massif, both in Queensland and the Territory, and are here regarded as shear zone formations. Without disputing the possibility of a derivation from sediments, the writer ventures to say that the re-arrangement and crystallisation of the constituents has been aided by movement on the bedding plane and by the introduction of mineralisers along the shear.

II. THE SOUTH-EASTERN OR KOSCIUSKO MASSIF.

Victoria, Tasmania and the Monaro district of New South Wales form a geological unit which has been an area of plateau uplift since the cessation of Permo-Carboniferous folding and mountain-building. Erosion to base level has taken place on several occasions, followed by renewed uplift and more or less faulting.

Each reduction of the plateau to base level has been followed by marine transgressions, of which the geological record of the Tertiary submergence alone has been preserved to a considerable extent. Thus in North-Eastern Tasmania, Southern and Western Victoria, and in the Riverina district of New South Wales, Kainozoic formations are frequent.

The faulting accompanying the great Mesozoic uplift was followed by the extension of the great diabasic sheets of Tasmania; and the Tertiary faulting, which produced Bass Strait, was followed by the basaltic eruptions of Central Victoria.

The principal alkaline effusions diagnosed in the south-eastern massif were those of Mount Macedon in Victoria, Regatta Point in Tasmania, and the nepheline phonolite dykes of Mount Kosciusko.

An interesting feature of this massif is the fact that while the general direction of the highlands is east and west, the fold

direction is north-south. The Cordillera in Victoria is formed by the fusion of a number of north-south ranges, probably through a general plateau uplift along an east-west axis.

III. THE CORDILLERAN BELT.

This area might be described as extending from Cape Howe and Mount Kosciusko on the south, to the vicinity of Mackay in the north. Although comprising many stratigraphical formations, the region is a geological unit in that the direction of folding is identical with the direction of mountain axes and maximum elevation.

Through this belt the earth movements have been of a compressional type, true fold movements of the mountain-building nature, right up to the Tertiary period, though in the southern portion of the belt, the Hawkesbury sandstone of the Shoalhaven and Sydney districts, is not greatly disturbed. Further north, in the Clarence and Ipswich districts, considerable fold movements were experienced after Jurassic sedimentation, and in the Ipswich and Burrum districts even Tertiary beds show some folding. The Mesozoic formations are, however, dipping at very steep angles along a line from Ipswich north-north-west towards Mount Brisbane, and bent into an anticlinal fold in the D'Aguilar Range. Considerable rolls are observed in the same beds in the Moreton Bay district. When we get further north to the Maryborough district we find the still higher Upper Cretaceous rocks sharply folded. This is also the case with the Styx River Cretaceo-Tertiary Coal Measures, north of Rockhampton. The Bundamba and Walloon formations are folded into a very sharp anticline between Beaudesert and Boonah.

All these fold movements are but repetitions of the same impulses which gave origin to the belt of coastal elevation.

Alkaline lavas also characterise parts of this belt at Gib Rock, Mittagong, Mount Barrigan, the Warrumbungle and Nandewar Mountains, the Canobolas, and the subalkaline eruptions of Prospect and Kiama, all in New South Wales. Also the volcanic rocks of south-eastern Queensland, including those of the McPherson Range, the Springbrook Plateau, the Main Range, Mount Flinders and the Fassifern Peaks, the Esk hills, the Glass House Mountains, the Yandina and Cooran heights,

and, further north, the Yeppoon Ranges and the Springsure district volcanics. The alkaline eruptions were in some cases followed by basaltic flows.* Trachyte tuff has been recorded by Maitland as far north as Mackay.

These eruptions belong typically to the western margin of the Cordilleran belt, though some of the groups are quite within the area of late folding, in which cases their existence is supposed to be indicative of trough faulting.

In South-eastern Queensland the Carboniferous and Permo-Carboniferous have been intensely folded, plicated, and altered. Strata assigned to those periods have been changed in the Stanthorpe-Texas district to hornfels, in Gympie to highly metamorphic slates and schists. This intense alteration, which is not noticed in the higher Jurassic strata, is in part due to the effect of the granitic intrusions in the early Mesozoic period. In New Guinea, where folding in Tertiary time was accompanied by Tertiary granitic intrusions, Kainozoic rocks are transmuted to an equal extent.

North Queensland.—North of the Tropic of Capricorn we find that the folding of the rocks corresponds with a series or plications forming arches, or festoons, round the Archean massif of the Northern Territory and North Queensland. The Gulf of Carpentaria regions are, in the writer's opinion, a part of the great north-central massif of the Territory and West Australia.

From the Sellheim gold and mineral field on the Suttor River, north and north-westwards to Mungana, the Tate and Georgetown, we have a region in which approximately east-west strikes predominate over those meridional or nearly so. It is an area in which the direction of folding has been east-west. Within this area occasional north-south folds are found as far north as Cooktown, secondary plications to the principal north-south axis now faulted beneath the sea, and possibly to some extent coincident with the Barrier Reef. The principal north-south axes within the area are the Cairns-Mareeba district (strike north-north-west) and the Kidston-Einasleigh district (strike north-south). The great majority of the strikes

* See "The Alkaline Rocks of Eastern Australia," by H. I. Jensen, Proc. Linn. Soc., N.S.W., 1908, and "The Volcanic Rocks of South-Eastern Queensland," by H. C. Richards, D.Sc., Proc. Roy. Soc. of Queensland, vol. xxvii, No. 7 (1916).

recorded in the aera are, however, more nearly east-west. Thus on the authority of Cameron (Q.G.S. Pubs. 151 and 219) the general strike in the region of Cave Creek, the Little Robertson, Western Creek, Georgetown, and McDonneltown, is east-west. At Mount Madden, Palmer Goldfield, east-west strikes, and in the Maytown to Limestone Creek belt north-west strikes, predominate (Jack, Q.G.S. Pub. 46). In the Cooktown tin area north-west strikes are also common. In the Irvinebank district the general strike is north-east (Skertchley, Q.G.S. Pub. 119), and in the Duff's Creek and Tate districts east-west (same author).

In the Ravenswood district the general strike is north-north-east (McLaren); and in the Cape River district west-north-west (Rands). The general strike in the Kangaroo Hills mineral field is east-north-east and east-west; and in the Cloncurry district east-west, west-south-west, east-south-east (Jack, and Rands, Q.G.S. Pub. 10, 104, 136, 153, &c.).

The west-north-west strikes are particularly noticed in schists and gneisses of great geological antiquity. This is the general strike direction also in the Precambrian formations of the Northern Territory, and the tectonic trend of the great granite intrusions which metamorphosed the schists of Northern Australia.

In greywackes and slates of Ordovician, Siluro-Devonian, and Devonian age the strike directions are more variable, while the Carboniferous and Permo-Carboniferous beds have been typically moulded on the Cambrian massif, and consequently strike in directions parallel with the outline of the massif.

The massif itself comprises, in addition to the bulk of Western Australia and the whole of the Territory north of the McDonnell Ranges, the Cloncurry-Burketown area, the Croydon Georgetown area, and the Cape York Peninsula west of a line running approximately from Fossilbrook to Princess Charlotte Bay. It is largely covered by Cretaceo-Tertiary deposits.

From Cooktown south along the coast to Kangaroo Hills, thence in a general west-south-west direction, through the Woolgar field to the Selwyn Range and probably on to the McDonnell Ranges, we have a festoon of Siluro-Devonian (?) rocks hidden here and there by the Cretaceous and Tertiary transgressions.

MAP
OF
AUSTRALIA
showing
Some important Trend lines

Figure 2

For further reference use Geological Map of Australia by Cotton and others (H. C. Robinson), Geological Map of Queensland (Q. Min. Index), Geological Map of the Northern Territory (*see* N.T. Bulletin No. 14).

Within the Northern Territory, on the massif itself, rocks later than Cambrian show little sign of folding. Even the Cambrian deposits in the Territory are often quite undisturbed (*see* "Northern Territory Bulletin" 14).

A Cambrian transgression formed limestones over a large area from Hall's Creek in Western Australia to Camooweal in Queensland. The fossils *Olenellus Hardmanni* and *Salterella Forresti* are indicative of the age of the horizon. A later Permo-Carboniferous inroad of the sea covered most of this area with shales and sandstones. Mr. H. Y. L. Brown has satisfactorily established the age of these beds by the help of fossils obtained at Anson Bay, Port Keats, and Borroloola. A Cretaco-Tertiary transgression or a series of oscillations in the late Cretaceous and early Tertiary period led to the formation of porcellanitic sandstones in numerous places, chiefly in the coastal belt, with fossil remains of belemnites, ammonites, gastropods, crayfish, &c. How far inland these late transgressions extended is not clear, owing to the horizontality of the Permo-Carboniferous rocks. The table sandstones of the interior have been regarded by Tenison-Woods as Desert Sandstone, but until some palæontological evidence can be found I think it is safer to regard them as Permo-Carboniferous.

The large area of Devonian rocks—the Burdekin series—which we see west of Townsville, probably occurs under the Basalts and Cretaceous beds from Lyndhurst to Boulia, and should be picked up between Urandangi and Boulia, from which region they most likely extend to the McDonnell Ranges, though covered at intervals by Cretaceous and Tertiary beds. In this belt the rocks overlying the Devonian would not be greatly folded.

From the Eungella goldfield, *via* the Sellheim field, westward through the Cape River district, until the series disappears under the Cretaceous, we have a festoon in which folding succeeded Permian sedimentation.

Thus as we proceed from Georgetown south-east towards Mackay, folding becomes progressively more recent, and when one gets south of latitude 21 deg. south, the rocks assume more and more the axial direction of the Cordilleran belt.

Movements in the Cambrian massif have been entirely of the plateau type, consisting of uplifts followed by long periods

of erosion and peneplanation. The earth fissures formed in the pre-Cambrian and Cambrian movements have not been obliterated by later folding. The problems to be studied in their connection are chemical—those of leaching, secondary enrichment, &c.

Plateau Uplifts in General.—Plateau topography is typical of most of the tropical regions of the earth. Thus the Saharan portion of Africa, the whole of Arabia, the Deccan in India, Northern South America (Venezuela, Columbia, and Guiana) and Northern Australia, geologically studied, are plateau regions. Most of the adjacent seas are Senkungsfelder. Perhaps the earth's rotation on its axis has something to do with this condition. In these regions (tropical regions) the trend lines, or axial directions, of mountain ranges are predominantly west-north-west in the southern hemisphere, and west-south-west in the northern hemisphere, a feature which is even more noticeable in comparing Palæozoic strike directions than in the study of Cordilleran axes. It is also significant that in temperate zones the main axial directions are north-west in the southern and north-east in the northern hemisphere.

The data obtainable so far are somewhat crude and have never been systematically collected with a view of pursuing this study, but the facts known to us point to a plasticity of the earth's crust in the Archean period, which caused the sub-crustal igneous magmas to take on directions analogous to the trade winds. If further studies can elicit more facts in confirmation of this rule, the planetesial hypothesis can be definitely abandoned and the Lamarckian theory of the earth's origin can be regarded as definitely proved.

Blue and White Quartz.—In McLaren's "Gold" (The Mining Journal, London) it is emphasised that the auriferous Archæan terranes of Western Australia, Deccan, and South Africa, are characterised by two kinds of quartz—an older blue quartz and a later white quartz. This characteristic has also been noticed in the pre-Cambrian of the Northern Territory. The hornblendites and amphibolites which antedate the granitic intrusions (*see* N. T. Bulletin No. 16, pp. 47 and 48) are frequently traversed by veins of this blue quartz. Definite evidence of the relative ages of the amphibolites and granites was obtained by the writer in the Margaret and Pine Creek

districts (*see* N. T. Bulletin No. 16). The blue auriferous quartz occurring in the hornblendites has been sheared ; it is frequently crossed by veins of white quartz, and is found principally as small leaders which are usually very rich in gold. Many of these leaders have been worked at the Maid of Erin Hill and Trig Hill, Pine Creek. The writer has not yet had a chance to examine the pre-Cambrian amphibolites of North Queensland, but Rands's description of the Ebagoolah goldfield shows that there is a close similarity between this field and the Northern Territory goldfields. In the Coen and Ebagoolah fields one would expect to get the same two types of quartz as in Western Australia and the Territory.

Graphite in Lodes.—The widespread distribution of graphite in the lodes of Western Australia, the Territory, the Cloncurry district, Ebagoolah district, Croydon, &c., is one of the pronounced features of the north-central massif. The writer has shown (N. T. Bull. 16, and in an official report on Croydon not yet published) that the graphite is probably of chemical origin, due to interactions between limestone, hydrogen, water, and iron minerals at high temperatures with probably iron-carbonyl as an intermediate product of the reaction. He can see no reason for the belief that any of these graphites have been derived from coal seams. In studying the Gympie graphitic beds under the microscope, the writer found the plumbagiferous beds derived from tuffy limestones (submarine calcareous tuffs) with marine fossil remains rather than plant beds, while the lode graphites of other districts are probably of hydato-igneous origin. In other parts of the world, as in Ceylon and in the New York province, graphites occur chiefly in highly metamorphic rocks, and are probably of hydato-igneous origin.*

In the Northern Territory, on the margins of the great and igneous intrusions, and, in general, on the strike lines of the pre-Cambrian crystalline limestone belts, as at Krana Creek (Margaret district), Uwatha Tableland (Upper Cullen River), we get frequent large areas of andalusite and chiastolite-sillimanite rock, very rich in graphitic carbon (*see* N.T. Bulletin 16). There can be little doubt that this graphite was formed chemically from the metasomatism and silicification of calcareous carbonate rocks, and limy shales.

* See "The Origin of Graphite," by H. I. Jensen, D.Sc., Economic Geology, Jan.–Feb. 1922.

Bitumen was obtained by Drill-Foreman Berry in 1911 in boring on a silver-lead-zinc lode in Cambrian limestone country on Cattle Creek, about 10 miles from McArthur Station. Ball has recorded anthracite from the Silver King lode in the Burketown Mineral District (Q.G.S. Pub. 232, p. 30). In the writer's opinion these occurrences probably have no connection with true coal seams, but are purely of chemical origin.

Magnetite-Hematite-Quartz Lodes or Beds.—McLaren in his work on "Gold" says: "By far the most characteristic rock of the Archæan group, and one always associated with the sedimentary members of the series, is a well-banded, generally much-contorted, hematite-magnetite quartz rock, of obscure origin. It has been thought to arise from silicification along shearing planes, but it may most reasonably be regarded as due to the metamorphism of ferruginous silicate and carbonate bands in depth, with resultant conversion into ferric oxide and silica."

Although the writer has not diagnosed this rock type in the Territory, the allied "hematite quartz" rock occurs frequently in the Rum Jungle, Margaret, Mount Ellison, and other districts, and, as far as the writer's experience goes, it is always a shear formation and not of purely sedimentary origin. In the Cairns district in a greywacke schist series of much later (Devonian ?) age we get hematite quartz and hematite-magnetite quartz rocks which are certainly shear formations, the shearing having occurred on bedding planes. The original sedimentary rock substance has been supplemented by silica and mineralisers from below.

The ferriferous shears are always most freely developed in the Territory in regions where amphibolitic rocks abound—a feature which certainly points to the derivation of much of the iron through transport by mineralising solutions from the ferriferous amphibolite to the shear zones. The shear zones are channels in which metasomatism is affected by the agency of mineralisers carrying iron from basic and ultra-basic schists and intrusives, which they are simultaneously metasomatising.

Thus, one may reasonably deduce that the frequency of hematite-magnetite quartz zones in the Archæan is a sequence of the abundance of basic and ultra-basic intrusives ino thes formations.

In North Queensland ultra-basic rocks are abundant from Almaden to Charleston and Georgetown. As in the Territory, they are older than the granites.

Chloritic Rocks and Schists.—Throughout the Northern Territory and North Queensland tin areas chloritic schists and chloritic rocks are of very frequent occurrence, and are extremely favourable host rocks for tin deposition. They are frequently topazised in the vicinity of the lodes. In the Territory we have these rocks at Hidden Valley, Horseshoe Creek, Mary River tin field, Mount Todd, &c. We have at Maranboy a closely allied rock, but so intensely silicified as to be akin to hornfels. In Queensland they are the dominant rocks in the Koorboora and Irvinebank districts. In the Territory the "chlorite" areas are of late pre-Cambrian age, metamorphosed by the early Cambrian granites. In North Queensland they are usually regarded as coeval with the Silurian Chillagoe series*. The chlorite schists are unfossiliferous and possess the textural characteristics of metamorphosed volcanic tuffs.

The writer has observed that the period of granite intrusion, which was pre-Cambrian in the Darwin district, was continued into the Cambrian in the McArthur district (Yah Yah Creek); and possibly that would also be its age in the Mount Oxide region (Burke). It is quite possible that the volcanic period that produced the tuffs was an early manifestation of the igneous activity which later led to the "Older Porphyry" intrusions, and occurred progressively later as it made east. Thus the Koorboora-Irvinebank series may easily be as late as Ordovician, and the granites here Carboniferous.

The formation of chlorite points to tuffs having been covered with some thousands of feet of sediment and depressed into the Upper-Middle zone of the earth's crust prior to the igneous and hydato-igneous activity. The same rock types more intensely metamorphosed in a lower zone, where minerals of an anhydrous nature would form, become magnetite-hematite-quartz hornfels. This is a frequent type at Maranboy (Northern Territory).

* I have, however, come to the conclusion that the North Queensland chlorite schists are older than the Chillagoe series and probably of Orvodician age.

The tendency for tin to leave the deeper zones of metamorphism and to deposit in the upper middle zone, where hydration is permitted by the temperature pressure conditions, is thus evidenced by the association of tin with chlorite rock. Obviously reaction $SnF_4 + SiO_2 = SnO_2 + SiF_4$ is not favoured by high-temperature pressure conditions, in which hydrous minerals are unstable. The silico-fluorides, like topaz, pycnite, are almost universally hydrous. The SiF_4, as soon as formed, reacts with silicates to form these minerals. The chlorite rocks are therefore best regarded, not as an indication of a definite geological age but as the typical alteration product of certain tuffs when depressed to the upper "middle" zone of the earth's crust during a period granitic intrusion.

Apically, Medially, and Basally Truncated Batholiths.—Professor Butler, in "Economic Geology," March, 1915, has shown that for batholiths of the same magma those apically truncated are more favourable to rich mineral occurrences than those medially and basally truncated. In general that holds true for the Territory, where the writer has investigated the matter. It is also the writer's experience that apically truncated batholiths are characterised by a more aplitic type of granite than usual, often called "sandy granite."

In areas of general plateau uplift, continued through great periods, there will naturally be extensive areas of granite, constituting medially and basally truncated batholiths. Those areas are not favourable to the prospector. Alluvial tin, gold, and wolfram occur widely on them in small quantities, but large lodes are few or absent.

It is on those parts of the massifs over which the schists and metamorphosed sediments are only partly removed, and the underlying granite exposed only here and there in valleys, o as a central boss with schists dipping away from it all round, that one would search with most prospect of success for payable lodes.

In the Territory the Maranboy and Coronet Hill fields are such areas. Tanami is another in which erosion has not yet exposed the granites anywhere. The heads of the Katherine, Alligator, Limmen, and McArthur Rivers are also in areas where apically truncated batholiths will be found. In North Queensland apically truncated stocks will most frequently occur around the edges of the northern massif, along the belt of erosion of the Silurian festoon moulded on the massif.

This is confirmed by the location on the map of the principal mineral fields of North Queensland. Commencing at Rocky River and running our pencil south, we pass through the Hamilton, Coen, Ebagoolah, and Palmer goldfields, the O.K., Chillagoe, and Tate mineral fields, Einasleigh and Kidston, and thence south-west through Gilberton, Woolgar, and after a Cretaceous overlap, the Cloncurry field. On the massif itself the areas offering most promise of new finds are the Woollagorang–Lawn Hills area on the border and those already mentioned in the Territory—viz., the Tanami area and the Upper Limmen, McArthur, Katherine, and Alligator River districts. These areas and the border festoon will yield mineral wealth for ages to come.

Nature of Lodes on the Massifs and Cordillera Compared.—The lodes of the massifs (*i.e.*, in pre-Cambrian formations) are frequently large and permanent. They vary from high grade to low grade. Many have been tried in the Territory after the richer surface ores have been worked out, and in numerous instances the magnificent early yields justified more thorough exploration of the deeper zones, although transport difficulties made it unprofitable to work any but the richer ores.

There is no doubt that, with improved communications and transport facilities, mines like the Iron Blow (Yam Creek), Mount Bonnie (Margaret River), Coronet Hill, Daly River copper mine, Eureka, and Evelyn will be reopened and worked for lower-grade sulphides.

When that time comes it will be essential to have a study made of the sulphides occurring below the water level to determine in the case of each mine whether they are primary, or of secondary origin. In an area of plateau movement it would be quite possible for bodies of carbonate and oxide to exist below a zone of secondary sulphides. This possibility, being of great economic importance, deserves close study.

The large permanent fissure lodes and shear zones of the massifs are frequently gossan-capped, passing into massive sulphides below. In the Cordilleran area a quartz matrix predominates, both in the surface and sulphide levels.

In the Palæozoic folded rocks of the Cordilleran area the lodes themselves have been so disturbed, both by Palæozoic and later folding, that they are reduced to discontinuous lenses.

SUMMARY AND TENTATIVE CONCLUSIONS.

1. North Queensland, from Cloncurry to Cape York, forms part of the North-Central massif of Australia, which is predominantly of pre-Cambrian age, and which has not been affected by any compressional forces since the early Cambrian.

2. Festoons of progressively more recent folded rocks envelop the massif.

3. The massif has been subjected to plateau movements only. As a result, the lodes on it are strong and permanent, with a likelihood of oxidised bodies occurring below the first sulphide zone encountered.

4. The apically truncated batholiths of the massif and in the Silurian festoon are most favourable for the prospector. Grano-aplites are the characteristic rocks of apically truncated stocks.

5. Basic eruptives, altered to amphibolites, two quartz types (blue and white), magnetite-hematite-quartz rocks, hematite-quartz rocks in shear zones, and lode graphite, are features of massif petrography.

6. The North-Central massif of Australia is characterised by Archæan trend lines in a west-north-west direction. Reference to Suess' "Das Antlitz der Erde" and to his maps showing the trend lines of the five continents will show that the dominant trend lines in the southern hemisphere are west-north-west for tropical, and north-west for temperate regions; and in the northern hemisphere east-north-east for tropical and north-north-east for temperate regions. This feature, being most pronounced in Archæan structures, points to greater plasticity on the earth's crust in Archæan times than in later periods, and affords confirmation of the Lamarckian theory of earth origin.

7. The Cordilleran belt of Australia, from the Kosciusko massif to Whitsunday Passage, is essentially a fold region or geosynclinal. Owing to intense folding it is not so favourable for the occurrence of strong continuous lodes as the massif areas.

8. The Cordilleran belt passes out under sea somewhere north of Mackay, and possibly swings out to New Caledonia, a large portion of the geosynclinal ranges having been resubmerged by extensive trough faulting.

Obviously, conclusions can only be tentative, as data are sadly wanting in regard to trend lines. Present-day mountain ranges not infrequently, as in the case of the Victorian Alps, do not correspond to the directions of folding. Certain propositions are, however, advanced in this paper for further investigation. Certain queries of world-wide geological interest arise.

Why are tropical regions essentially plateaux and submerged plateaux regions? Were equatorial regions in Archæozoic times dominantly continental? Was there a strong rock flowage in the upper earth's crust giving rise to west-north-west trends in southern latitudes and west-south-west trends in northern?

Other matters touched on, as, for instance, the questions of lodes and mineral resources, are more purely of Australian interest.

The questions raised are not for one geologist to solve. They require the collaboration of all.

Geology and Petrology of the Enoggera Granite and the Allied Intrusives.

By W. H. BRYAN, M.Sc., Lecturer in Geology, The University of Queensland.

PART II.—PETROLOGY.

(Plates I.-III.)

(*Read before the Royal Society of Queensland, 26th June, 1922.*)

I. INTRODUCTORY.

In November, 1914, the author had the privilege of reading before this Society the first part of a paper entitled "Geology and Petrology of the Enoggera Granite and the Allied Intrusives."[1] This dealt with the general geology of the area, and it was the author's hope that it would be followed, after a short interval, by the second part of the paper, which was to deal more particularly with the Petrology. Much of the work required for this part of the paper had been done, but its publication has been very much delayed, chiefly as the result of the author's absence abroad with the Australian Imperial Forces.

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[1] Proc. Royal Soc. Qld. Vol. XXVI. p. 141.

II. GENERAL PETROLOGY.

The rocks dealt with fall into two main groups—viz., the granitic and granodioritic rocks forming the outcrops at Enoggera, Green Hill, and Kedron Brook, and intrusives of a rhyolitic and porphyritic nature which are intimately associated with the former series, and which are believed to be genetically related to them.

The former group is called locally the "Enoggera Granite," and is best known from the building stone which has been very largely used in and about the city of Brisbane, and which is obtained from a quarry on the left bank of the Enoggera Creek. This rock has been dealt with by Professor H. C. Richards, D.Sc., mainly from the economic aspect.[2] This particular variety cannot, however, be regarded as typical either of the group of granitic rocks as a whole, or even of those forming the outcrop of the principal Enoggera area.

The most marked feature of the granitic group petrologically is the wide variation of type to be met with for such a restricted area of outcrop. This variability is both chemical and textural. Mineralogically the variation is not so marked, the different rock types resulting rather from differences in the proportion of the minerals present than in actual differences in character and appearance of the minerals themselves.

In the face of such wide differences in the field it is at first difficult to generalise, but it seems to the writer that this variability can be revolved into—

(1.) Two main phases, which for convenience we may term the Pink and the Grey, which differ chemically as shown by a comparison of the Rock Analyses E1 and E4, and mineralogically in the proportions of the minerals present.

[These were referred to in the earlier part of this paper (p. 150) as the "adamellite type" and "granodiorite type" respectively. While the author has every reason still to regard the "Grey Phase" as being essentially granodioritic, he now doubts the wisdom of referring to the "Pink Phase" as an adamellite type. If one

[2] Proc. Royal Soc. Qld. Vol. XXX. p. 101, and Plate X., fig. 13.

uses Hatch's simple criterion[3] then since the Orthoclase and Plagioclase felspars are present in approximately equal amount the rock is an adamellite. Further, the analysis of the Pink Phase (Analysis I.) is remarkably close in all its essentials to that quoted by Hatch p. 179, as "iv. Adamellite, Shap."[4] However, these analyses also agree in differing somewhat sharply, both in amount and proportion of the alkalies, from Analyses I., II., and III., which are presumably more typical adamellites.]

(2.) A wide variability within both the light and dark phases, which, however, is textural merely and not chemical, as is seen by a comparison of the mineral contents of specimens very dissimilar texturally, which show plagioclases of the same chemical composition and in which the other minerals are identical.

(3.) In addition to the former varieties we occasionally get others which depart rather widely from the more typical rocks in the proportion of the minerals present. Of these, only one forms outcrops of any importance, and this is remarkable in that it appears to have some important characteristics in common with each of the phases. It is not so much a mineralogical average of the Pink and Grey Phases as a mineralogical mixture. At first sight it appears to represent a connecting link between the phases, but the discussion of this question is deferred. The rock in question is to be seen outcropping at the Quarry on Enoggera Creek.

One might reasonably expect that such marked chemical differences as those shown in the analyses (E1 and E4) of the two phases would be reflected in their distribution in space or in time.

With regard to distribution in space, rocks representative of the Pink Phase cover roughly three-quarters of the main Enoggera area of outcrop and all of the Green

[3] Hatch, "Petrology of Igneous Rocks," p. 164.

[4] Op. cit. p. 171.

Hill area, while the Grey Phase occupies one-quarter of the Enoggera area and the whole of the two outcrops at the Kedron Brook area. Further, the latter phase is usually restricted to the more deeply dissected or more central portions of the Enoggera area, the highest points and peripheral portions being almost invariably occupied by the aplitic, fine-grained and "sandy" granites which form a distinct type of the Pink Phase. The vertical section in the central part of the Enoggera area, obtained by descending into the valley of the Enoggera Creek from the heights lying to the north, gives in descending order the following sequence:—

$$\left.\begin{array}{l}\text{Aplitic and ``sandy'' granites}\\ \text{Typical Pink Phase}\end{array}\right\}\text{Pink Phase.}$$

Pink Phase with included fragments of Grey Phase.
Typical Grey Phase.

A similar sequence is often, but not always, found in passing from the periphery towards the centre of the area.

This arrangement of the dark and light phases seems at first glance to suggest a differentiation into two main types as the result of gravitative separation, but a closer study of the relationship of the phases does not support such an hypothesis.

The only indications which have been noted which suggest any difference in the time of intrusion of the two phases appear at first sight to be contradictory.

In some sections the Grey appears to intrude the Pink Phase as dykes, but in many other sections it is definitely surrounded by the Pink Phase and forms irregular inclusions or "segregations" of very variable size. While some of the smaller of these are undoubtedly segregations in the strict sense of the word, the vast majority of the larger ones appear to be fragments caught up by the enclosing magma.

There is thus some evidence that part at least of the Grey Phase is later in age than the Pink, but the weight of evidence points to the Pink as being the later phase. These two groups of evidence, though apparently contradictory, may perhaps be reconciled in the following way:—The Pink appears to have broken through the Grey rock, carrying fragments of varying size with it. Later the under-

lying dark rock may, as the result of heat or pressure changes, have become molten again and have been forced up into the cooler overlying Pink Phase as intrusions.

The field evidence thus appears to indicate that the two phases are not the result of differentiation in place, either by gravitative or other methods, and that the Pink Phase is younger than the Grey, and that, further, the aplitic and sandy granites are later than the more normal type of the Pink Phase. Thus we see that the order of succession is Grey Phase followed by typical Pink Phase, which in turn is followed by the aplitic and "sandy" granite types of this phase, with finally a reversion to the basic or Grey Phase. This is the order of primary differentiation of Brögger, who, to quote Harker, believes in "an order of increasing acidity with in many instances a final reversion to basic types."[5]

It is interesting to note that this relationship is strictly analogous with the sequence of intrusions in New England, the Moreton district of Southern Queensland, and that of Charters Towers of Northern Queensland, but more detailed comparisons with these areas are made later in the paper.

The following rock analyses give a general idea as to the chemical relationships of the two phases. Analysis E1 is that of a rock selected as typical of the Pink Phase, while Analysis E4 is that of a rock typical of the hornblendic type of the Grey Phase. Analysis E2 is the only other analysis from the area and is that of the "Enoggera Granite" used largely as a building stone, and which mineralogically presents important points of similarity with both phases. Analysis E3 is that of the Mountain Camp rock, a few miles to the north of Enoggera.

The precise position of E2 and its relationship to the Pink or to the Grey Phases is a question about which the author has long been in doubt. In appearance it resembles neither a typical granite nor a typical granodiorite. The grey colour, the relative basicity of the plagioclases, the absence of pink orthoclase and the abundant pyrites were all points in common with the Grey Phase, but the high acidity of the rock and the marked

[5] Eruptivgesteine des Kristianiagebietes," II. (1895), pp. 165-181.

preponderance of biotite and the specific gravity were factors in common with the Pink Phase.

TABLE 1.

——	Pink Phase. E 1.	Grey Phase. E 4.	(?) Hybrid. E 2.	Calculated Rock. A.	Mountain Camp Rock. E 3.
SiO_2	73·52	61·10	71·50	70·41	61·54
Al_2O_3	11·05	19·24	14·13	13·10	19·03
Fe_2O_3	Nil	} 4·66 {	0·60	} 3·53 {	Nil
FeO	3·15		3·23		5·04
MgO	1·03	2·56	1·17	1·41	2·97
CaO	1·70	5·25	2·70	2·59	4·90
Na_2O	4·08	2·82	2·97	4·01	2·84
K_2O	3·99	1·68	2·86	3·41	2·76
$H_2O +$	0·44	1·31	0·32	0·66	0·35
$H_2O -$	0·16	0·64	0·10	0·28	0·10
CO_2	..	..	..	..	..
TiO_2	0·20	..	0·41	..	0·72
P_2O_5	0·15	..	0·35	..	0·08
Total	99·48	100·26	100·34	99·40	100·33
Sp. Gr.	2·58	2·71	2·59	..	..
NORM: Quartz	30·24	14·82	34·32	..	15·00
NORM: Orthoclase ..	23·35	10·01	16·24	..	16·68
NORM: Albite	34·58	32·49	25·15	..	24·10
NORM: Anorthite ..	..	26·13	11·40	..	24·46
NORM: Diopside	6·34	..	..	..	..
NORM: Corundum ..	..	1·43	1·84	..	2·24
NORM: Hypersthene ..	4·67	11·55	8·52	..	16·64
NORM: Magnetite ..	..	1·86	0·93	..	..
NORM: Ilmenite	0·46	..	0·76	..	1·37
NORM: Apatite	0·34	..	0·67	..	..
Symbol	I. 3.1.3.(4) Alaskose	II. 4.3.4 Tonalose	I. 3.2.3 Tehamose	.. ..	II. 4.3.3(4). Harzose

This rock, as the result of the opening of new quarries, has proved to be considerably more extensive than the author first thought. If, as its mineralogical contents and chemical composition both suggest, it is related to *both* phases, there are only three possible modes of origin—

(1.) That it is the parent magma from which both the Pink and Grey Phases sprang;

(2.) That it is an intermediate member of a series E1-E2-E4, thus linking the two phases; or

(3.) That it is the result of admixture of the Pink and the Grey Phases.

The first idea that it may represent part of the parent magma or undifferentiated portion is refuted by the evidence as to the two main magmatic series in Southern Queensland, to be discussed more fully later in the paper. Further, in the light of modern petrology we can hardly postulate the splitting of such a magma as that represented

by Analysis E2 into two parts such as those we see in analyses E1 and E2. Such an hypothesis as the second might explain the intermediate chemical composition, but does *not* explain the mixed mineralogical nature of the rock.

The only alternative remaining is that this curious rock is produced by admixture of two distinct rock types. It seems to be what Harker terms "a hybrid."

By weighting the Analyses E1 and E4 in the proportion 3:1 (a ratio already mentioned as that of the outcrops of the two phases in the somewhat deeply dissected Enoggera area) we obtain the hypothetical rock which would be produced by the admixture of the Pink and Grey Phases in the proportions in which we believe them to exist. The chemical composition of such a rock is represented by Analysis A, which is seen to agree quite closely in many respects with Analysis E2.

In comparing the calculated Analysis A with the actual Rock Analysis E2, it is seen that while the value of the calculated CaO is somewhat less than the actual, both the alkalies are considerably in excess, although the proportion K_2O : Na_2O is much the same. This is not unexpected, for Harker[6] in discussing the calculation of the chemical composition of hybrid rocks points out that while in bulk the hybrid rock must be a linear variation of the two unmixed rocks, differences may be expected in the chemical composition of the rock specimens analysed. The example quoted by this eminent authority resembles the present case in that the CaO found in the hybrid rock is less than the calculated, the difference being that in Harker's case the discrepancy is considerably greater. This is explained by Harker as probably due to difference in the rate of diffusion of CaO on the one hand and of the alkalies on the other. Hence the divergences to be expected are precisely those found to exist in the present case. The calculated value of CaO will be less than that of the actual, while that of the alkalies will be greater and further as the rates of diffusion of the potash and soda molecules are very nearly identical, the proportion K_2O : Na_2O as calculated should agree very nearly with the proportion found by actual rock analysis.

[6] "The Natural History of Igneous Rocks," p. 358.

If, then, the rock is a hybrid, we might expect it to betray its mixed origin more directly in its chemical composition. The most remarkable feature of the Analysis E2 is the practical equality and low values of CaO, Na_2O, and K_2O. In this combination the analysis differs markedly from all the analyses of average acid plutonic rocks compiled by Clarke, Daly, and Osann, to which the author has access. Further, a search was made through the ninety-six analyses of rocks placed in the same subrang (Tehamose) in Washington's "Superior Analyses of Fresh Rocks" for similar types.

A noticeable feature of the analyses was the wide range in the absolute and relative values of CaO, Na_2O, and K_2O, a point to which the author naturally gave much attention. One analysis was found which is remarkably close to E2, especially in the alkalies and alkaline earths; but—and this the author considers very significant—it is not strictly an igneous but a metamorphic rock. It is No. 9 in Washington's list for the subrang, and is described as a granite gneiss from Virginia, U.S.A.[7]

The analysis next most like that in question is No. 2, a Hypersthene Adamellite from Havnefjord, Ellesmere Land, and is patently not a normal granitic type. No. 61, Tonalite Porphyrite, from the Tyrol, and No. 65, Adamellite from Switzerland, approach the Enoggera hybrid in some respects, and a curious series of rocks from Japan, notably the "Granite" No. 79, seems to provide a somewhat similar rock.

The evidence, on the whole, seems to uphold a hybrid origin for the Enoggera building-stone.

It is interesting to note here that Jensen suggests that the Cooroy Monzonite and the Pt. Arkwright Porphyrite, both some 75 miles to the north of Enoggera, are "made up of a mixture of a dioritic magma with the aplitic differentiation product . . . ."[8]

Further consideration of this important question of hybridism in the Enoggera area will be given in that portion of the paper dealing with comparisons of the local granitic rocks with those of other areas.

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[7] "A Description of the Quantitative Classification of Igneous Rocks," 1918, p. 81.

[8] "Geology of the Volcanic Area of the East Moreton and Wide Bay Districts, Queensland." Proc. Linn. Soc. N.S.W. 1906, p. 132.

(III.) PETROGRAPHY.

(*a*) THE PINK PHASE.

This phase is characterised by its high acidity and the consequent presence of quartz in considerable amount; by its pink orthoclase, which is usually slightly in excess of a white soda rich plagioclase, and which gives the rock its typical colour; and by biotite, which is usually present though not in any great amount. Hornblende is either absent or rare. Pyrites is absent. Associated with the Pink Phase proper are modifications of it of an aplitic and granophyric nature, which occur generally near the margins of the granite and capping the higher hills, and sometimes as distinct intrusions through the Pink Phases. These modifications are slightly later in time of intrusion than the typical pink rocks, and are almost certainly the equivalents of the "Euritic" series of Andrews and the "Aplites and Sandy Granites" of Saint-Smith in New England and Stanthorpe respectively (*see* Table II.). In the Enoggera area they are so intimately associated with the Pink Phase proper that it does not seem advisable to treat them as a separate group.

The following descriptions give some idea of the rock types found in this phase.

The bracketed numbers refer to the special "Enoggera" collection of rocks, while the other numbers are those of the collection of Microslides. Both are the property of the Geology Department, University of Queensland.

(*G. 1*) 141. (*See* Micro-photograph Pl. II., No. 1, and analysis E1.)

Specimen from southern part of main Enoggera mass.

Megascopic.—A pink holocrystalline, porphyritic rock, composed of medium-sized phenocrysts of quartz, pink orthoclase, white plagioclase and black mica set in a fine-grained flesh-coloured ground mass.

Microscopic.—The porphyritic character of the rock is marked and the proportion of phenocrysts to ground mass somewhat variable (Sempatic to Dopatic of Iddings). The *ground mass* is made up for the most part of quartz and felspar, sometimes irregularly intergrown, with occasional

small crystals of green biotite. The *quartz phenocrysts* are from 1-3 mm. in diameter and occur as allotriomorphic and rounded crystals, frequently fractured and containing numerous dust-like inclusions. In addition to these there are other small inclusions of biotite and larger ones of orthoclase and plagioclase. In one quartz crystal is enclosed an aggregate of quartz and felspar closely resembling the ground mass, but this may be the infilling of a deep embayment. *Orthoclase* occurs as hypidiomorphic phenocrysts which are considerably altered. These often include patches of another felspar intergrown in perthitic fashion. The *plagioclase phenocrysts* prove to be Albite-Oligoclases, and occur as large hypidiomorphic crystals which exhibit twinning on both the Carlsbad and Albite laws. *Biotite* occurs as brownish-green phenocrysts which become reddish-brown on alteration, and which show the characteristic strong absorption and perfect cleavage. Inclusions of zircon and apatite are sometimes found. *Magnetite* occurs in idiomorphic crystals and a few needles of *Apatite* are present. *Zircon* is present in small amount.

Order of consolidation of phenocrysts.—Normal.

In the ground mass quartz and orthoclase solidified at approximately the same time.

Name.—Granite Porphyry.

Note.—Among the many recommendations embodied in the "Report of the Committee on British Petrographic Nomenclature" is one that "The name granite-porphyry is ambiguous, and should not be used." This name has found considerable use in Australian petrographic literature, where it has a quite-definite meaning. The rock described above is so like many other Australian so-called "Granite-porphyries" that, principally for purposes of correlation, the author has deemed it wise to retain the term.

(*G.2*) 150. (*G.4*) 152.

These two specimens also come from the southern part of the Enoggera area. They are very like the rock described above in most respects, but there is seen in these slides a definite tendency for the felspar phenocrysts to be closely grouped together.

(*G. 8*) 156.

This specimen comes from the N.N.E. portion of the main Enoggera outcrop.

Megascopic.—A pink medium-grained rock made up of colourless quartz, pink orthoclase and white plagioclase, together with a little green mica.

Microscopic.—Holocrystalline rock of medium and fairly even grain. *Quartz* occurs in allotriomorphic crystals from 1-4 mm. in diameter. It is fresh, shows radiating fractures, and contains numerous large inclusions of felspar and many dust-like inclusions. *Orthoclase* is present generally in somewhat altered crystals, from 2-4 mm., showing Carlsbad twinning. Inclusions of both plagioclase and biotite occur. The *Plagioclase* felspar is a somewhat acid andesine. It occurs in smaller crystals than the orthoclase, and shows both Carlsbad and Albite twinning. Microcline is also present showing the characteristic combination of Albite and Pericline twinning. *Biotite* occurs as a few comparatively small dark green crystals which are partly altered to chlorite and contain a few inclusions of apatite. *Magnetite* is present in small amount and shows in places alteration to Limonite.

Order of consolidation.—Normal.

Name.—Biotite Granite.

(*G. 9*) 157.

This specimen comes from N.N.W. part of the Enoggera area.

Megascopic.—A medium-grained pink rock made up of colourless quartz, pink orthoclase, cream plagioclases, and a dark mica.

Microscopic.—Holocrystalline, medium grained. *Quartz* occurs as numerous allotriomorphic and interstital crystals from 1-3 mm. in diameter, considerably fractured, with inclusions of plagioclase, orthoclase, biotite, and apatite, and numerous small dust-like inclusions. Quartz also occurs intergrown with orthoclase and rarely as inclusions in orthoclase crystals. *Orthoclase* occurs in hypidiomorphic and allotriomorphic crystals from 1-3 mm. in diameter. It usually shows some alteration to sericite or other micaceous products. It is sometimes intergrown with quartz and

often shows inclusions of plagioclase, biotite, and quartz. The principal *Plagioclase* present is an albite-oligoclase, but an acid andesine is also present; and further, a zonal structure is sometimes seen. These felspars vary from 1-3 mm. in diameter and show Albite twinning commonly and Pericline twinning occasionally. They contain as inclusions crystals of biotite. *Biotite* occurs as brown and light green crystals strongly pleochroic, with inclusions of *Apatite*.

Order of crystallisation.—Normal.

Name.—Biotite Granite.

(*G. 26*) 422.

This is typical of the outcrop of the Pink Phase forming the Green Hill area to the south of the main Enoggera area. (*See* Microphotograph Plate II., No. 2.)

Megascopic.—This is a holocrystalline, porphyritic rock made up of phenocrysts of colourless quartz, white felspar and black mica set in a fine-grained pink ground mass. The rock is somewhat darker in appearance than the specimens from the principal area described above, and differs from them in the almost complete absence of phenocrysts of pink orthoclase.

Microscopic.—Holocrystalline, porphyritic. The medium size of the felspar phenocrysts, the fine-grained ground mass and the general arrangement, including the tendency of the felspar phenocrysts to form clusters, are all characters in which this rock approaches very nearly the rocks from the southern part of the main Enoggera area. (Compare Nos. 1 and 2 of Plate I.) The ground mass is made up of a microcrystalline mosaic of quartz and altered felspars, which, judging by the pink colour of the ground mass as seen in the hand specimen, are mostly orthoclase.

Quartz occurs as comparatively small rounded crystals usually from ½-1 mm. in diameter. Further, this mineral is not so abundant as in the specimens described above. *Orthoclase* phenocrysts are rare. The *Plagioclases* present are all strongly zoned, so that it is difficult to calculate from them the proportion of lime to soda in this rock. *Biotite* of the usual type is present. *Magnetite* and *Apatite* are present in very small amount.

Name.—Granite (Granodiorite?) Porphyry.

Associated with the Pink Phase, but a little later as regards time of intrusion, are aplitic and granophyric rocks which, however, do not merit detailed descriptions, since they are quite normal in most respects. In the former, however, flakes of molybdenite are occasionally found, while the latter sometimes show very beautiful micrographic intergrowths of quartz and orthoclase. (*See* Plate II., No. 3.)

(*b*) The Grey Phase.

Under this heading are included a number of rock types which, though they differ in some respects, have in common several characteristics which mark them off clearly from the "Pink Phase." In general the rocks of this phase are of a grey colour. Quartz is not so abundant as in the other phase (pink orthoclase is absent), and the plagioclases are more calcic, the phenocrysts usually being acid andesine and the felspars in the ground mass an intermediate andesine. Hornblende is usually present, sometimes in great abundance. Pyrites is invariably present, sometimes in considerable amount.

The rocks of this phase vary between two types. Of these the first is characterised by the very strong development of numerous long prismatic and acicular crystals of hornblende, which give the type quite a distinctive appearance. This rock occurs as inclusions, and larger masses set in and surrounded by the Pink Phase. They are evidently the remnants of an older rock. Although they are marked off from the enclosing mass by a well defined boundary, there is evidence that the hornblendic rock has been in some cases somewhat modified by the enclosing acid magma. In particular, one very interesting rock has resulted from a partial mixing of the two types. In the hand specimen it suggests mechanical mixing rather than chemical intermingling, although evidence of chemical interaction is seen on a closer inspection. The specimen examined was obtained from Portion 373, parish of Enoggera, and presents a curious appearance, irregular pink patches being scattered through the dark hornblendic rock. Numerous rounded quartz blebs occur sporadically throughout the rock, and each is surrounded by a very distinct corona of ferro-magnesian minerals. This suggests that at least some chemical interaction took place.

The second type of Grey Phase is not nearly so conspicuous as the first, but is probably present in greater amount, occupying as it does a considerable portion of the western and north-western portions of the Enoggera area. This type is finer grained, of a grey colour, has considerably more biotite present (usually in small crystals), and often has present quartz and felspar intergrown to give a rudimentary granophyric structure. The plagioclases are again andesines, and pyrites is always present. This type is sometimes found as inclusions in the Pink Phase and occurs as small zenoliths in the Enoggera (?) Hybrid. (*See* Microphotograph Plate III. No. 8.)

(*G. 44*) 416.—Specimen from Portion 374, parish of Enoggera.

This is representative of the hornblende rich type of the Grey Phase. (*See* Microphotograph Plate II. No. 4, and Analysis E4.)

Megascopic.—This rock has a remarkable appearance in the hand specimen. Numerous long slender crystals of hornblende, ranging up to 8 mm. in length and averaging about 4 mm. are set in a fine-grained light-coloured base and give the rock a pseudoporphyritic character. Pyrites is present in small amount.

Microscopic.—Fine-grained holocrystalline for the most part, but with large crystals of hornblende. *Quartz* is present but not very conspicuous, occurring as small allotriomorphic crystals and irregular patches. The felspars are for the most part clouded with decomposition products, but seem to consist for the most part of plagioclases. Some of the altered felspathic material shows a tendency for vague intergrowth with the quartz, and this is presumably *Orthoclase.* The plagioclases still show indistinctly traces of Albite twinning, very few of them being determinate. Those sections capable of determination by the Michel-Levy method show a variation from *intermediate to basic andesines. Hornblende* occurs in numerous elongated, relatively large crystals, which give an apparently prophyritic character to the rock. This impression is contradicted by two facts—first, there is no sign that the hornblende is present in two generations; and second, that the small plagioclases are idiomorphic to

these large hornblende crystals, showing clearly that at least the latter part of the growth of the hornblendes was subsequent to the consolidation of the plagioclases. This is, of course, seen best in prismatic sections of the hornblende, transverse sections often showing beautifully idiomorphic outlines with both sets of cleavages well developed. The mineral is light-green in colour, strongly pleochroic, and shows alteration to Chlorite. *Biotite* is very rare, but those few small crystals present are definitely idiomorphic to the hornblende. *Augite* is present in three very small crystals. *Magnetite* is present in considerable amount, but is largely pseudomorphous after *Pyrites*. *Sphene* and *Apatite* are present, but in very small amount.

Order of consolidation.—Biotite, Andesine, Hornblende, Orthoclase, Quartz.

Name.—Hornblende Quartz Diorite.

(*G. 41*) 345.—Specimen from near "The Summit," Taylor Range.

This forms a connecting link between the more typical hornblendic rock (G. 44) on the one hand and the biotitic rock (G. 14) on the other.

Megascopic.—A grey holocrystalline fine-grained rock, made up for the most part of white plagioclase and dark hornblende, together with very small flakes of biotite and numerous small crystals of pyrites.

Microscopic.—Holocrystalline, fine-grained. *Quartz* occurs as interstital growths, which (since the other minerals are strongly idiomorphic) are bounded by numerous short straight lines running at various angles, thus giving a curious graphic appearance to the mineral. Other somewhat larger plates are seen enclosing smaller crystals of all the other minerals. *Orthoclase* occurs as a few comparatively large, irregular crystals (up to 3 mm.), idiomorphic only to the quartz and showing perthitic intergrowths with another felspar. *Plagioclase* is present as numerous, mostly small, idiomorphic crystals, showing fine Albite twinning, but with a zonal extinction pointing to a considerable variation in chemical composition in each individual. In addition to these felspars is a large irregularly rounded crystal of plagioclase. The round outer

edge of this is optically discontinuous with the remainder, and is evidently a "reaction rim." The crystal proper shows both Carlsbad and Albite twinning and is considerably larger and quite different in appearance from the plagioclases of the enclosing rock. It is evidently a xenocryst. Unfortunately the section is in such a direction that the plagioclase is indeterminate. *Hornblende* occurs as numerous acicular crystals showing marked pleochroism and in some stouter crystals, these latter showing intergrowths with biotite. *Biotite* is present in small amount, generally in irregular patches associated with the hornblende. *Pyrites* occurs as numerous small crystals scattered throughout the slide. *Apatite* is present as abundant minute crystals.

Order of consolidation.—Normal.

Name.—Hornblende Microgranodiorite.

(*G. 14*) 418.—Specimen from western part of area.

This is representative of the second or biotitic type of the Grey Phase.

Megascopic.—A grey fine-grained holocrystalline rock composed of occasional phenocrysts of quartz and white felspar set in a grey even-grained ground mass. Some small veins of pyrites are apparent.

Microscopic.—Only one undoubted phenocryst (an altered felspar) was seen in the slide examined, the rock being made up of a fine-grained but somewhat variable aggregate of quartz felspar hornblende and biotite. The quartz occurs in very irregular crystals moulded about and enclosing all the other minerals. Occasionally, however, the quartz crystals have moulded about them a discontinuous ring of small ferro-magnesian minerals. *Orthoclase* is present as hypidiomorphic crystals which sometimes show simple Carlsbad twinning. *Plagioclases* are numerous and seem to be divisible into two groups, the first a medium oligoclase and the second an oligoclase-andesine. A felspathic xenocryst with similar outline and reaction phenomena to that described above in No. 345 is present in this slide. It shows no twinning, however, and resembles anorthoclase in general appearance. *Hornblende* occurs in comparatively large elongated green crystals which

are largely altered into chlorite. *Biotite* is present as numerous flesh flakes of a brown colour. The ferro-magnesian minerals show a distinct tendency towards segregation into definite groups. *Magnetite* occurs as fairly numerous crystals. *Apatite* is present as very small needles generally included in the other minerals. *Sphene* and *Zircon* are also present, but in much smaller amounts.

Order of consolidation.—The order of consolidation is not normal, and the various minerals "overlap" very much more than is usually the case. Some of the plagioclases are definitely earlier than some of the hornblendes, while others are just as definitely later. The same overlapping is noticeable with hornblende and biotite. Even some of the quartz crystals appear to be earlier than the small flakes of biotite which partly surround them. The ferro-magnesian minerals often appear as clusters illustrating the "together-swimming structure or synneusis struktur" of Vogt[9], which is characteristic of those minerals segregated from the magma at an early stage. But in this case they were certainly preceded by some at least of the plagioclases.

Name.—Granodiorite.

(*G. 18*) 421.—Specimen of Grey Phase from the southern of the two Kedron Brook outcrops.

Megascopic.—A grey rock made up of small phenocrysts of felspar and a ferro-magnesian mineral set in a very fine ground mass.

Microscopic.—Holocrystalline, porphyritic with small to medium phenocrysts set in a very fine-grained microcrystalline ground mass of quartz and felspar. *Quartz* occurs as rounded and embayed phenocrysts from ·5-1 mm. in diameter. *Orthoclase* is present as medium-sized phenocrysts very much altered by weathering. *Plagioclase* is present as medium-sized phenocrysts of Andesine very much altered, *Biotite* is present as ragged crystals, and *Hornblende* as long prisms both considerably altered.

Name.—Granodiorite Porphyry.

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[9] "Magmatic Differentiation of Igneous Rocks," Journal of Geology, Vol. xxix. p. 321.

(c) The (?) Hybrid Rock.

This occurs as a patch a few acres in extent on the left bank of Enoggera Creek and about one-third of a mile from the eastern edge of the granitic mass. It is entirely surrounded by rocks typical of the Pink Phase. This rock has been quarried and used to some extent in public buildings in Brisbane and for kerbing purposes. It is known commercially as the "Enoggera Granite." (*See* analysis E. 2 and microphotograph Plate III., No. 7.)

(*G. 6*) 154.—From the Quarry, Enoggera Creek.

Megascopic.—In the hand specimen the preponderance of the light-coloured "salic" minerals over the dark-coloured "femic" minerals and the small size of individuals, and especially those of the latter group, give to the rock a somewhat curious "pepper and salt appearance,"[10] and a general absence of relief.

Microscopic.—Holocrystalline, medium-grained, the grain size, however, being somewhat variable, the resulting texture resembling the "seriate porphyroid fabric" of Iddings. *Quartz* occurs as allotriomorphic crystals from 1-3 mm. in diameter, fresh, generally unbroken, enclosing numerous large crystals of felspar. It also occurs commonly with orthoclase in micrographic intergrowths. *Orthoclase* occurs as hypidiomorphic crystals of varying size, sometimes as inclusions in quartz and sometimes in micrographic intergrowths. Carlsbad twinning is seen and inclusions of another felspar tend to give a rudely perthitic structure. It is usually considerably darkened and altered. The *Plagioclases* present are mostly intermediate andesine. A few crystals of oligoclase-andesine are present, and in addition there are a number of zoned plagioclases. Albite twinning is common, and Pericline twinning combined with Albite is not infrequent. All these felspars are darkened as a result of decomposition, and while some crystals are hypidiomorphic, the majority of them, and particularly the more basic, show irregular embayed and corroded outlines. *Biotite* occurs as rather small brown and green crystals, sometimes considerably bleached and altered into chloritic material and usually strongly pleochroic. *Hornblende* occurs very sparingly as green idiomorphic pleochroic crystals. *Pyrites* occurs commonly, generally in

[10] H. C. Richards, Op. cit. p. 102.

association with the ferro-magnesian minerals, both as well-shaped individual crystals and somewhat irregular clusters. *Magnetite* and *Apatite* are also present in small amount.

Order of consolidation.—Normal.

Name.—Biotite Granodiorite.

It is difficult to reconcile this rock mineralogically with either the Pink Phase or the Grey Phase. The abundance of quartz and the great excess of biotite over hornblende are points in comon with the former, while the absence of pink orthoclase, the nature of the plagioclases, and the abundant pyrites are more like the latter.

A comparison of the soda and lime content in analyses E. 1, E. 2, and E. 4 would lead us to expect in this rock plagioclases intermediate in character between those of the Pink and Grey Phases, and the calculated norms also predict such a result. However, measurements of the extinction analyses of suitable sections of felspars (Michel-Levy's method) in many specimens, actually give the following result:—

Pink Phase—Phenocrysts, 5 degrees; ground mass, 10 degrees.

Grey Phase—Phenocrysts, 9 degrees; ground mass, 15 degrees.

(?) *Hybrid*—Mostly 14 degrees; a few 9 degrees; some zoned.

The plagioclases in this rock, and particularly the more basic, frequently show corrosion, which suggests that they are xenocrysts from the Grey Phase.

This rock has, in addition, other features of special interest. The most remarkable of these is the abundance of primary pyrites, which occurs as individual crystals, sometimes of comparatively large size, and clusters of crystals scattered sporadically through the rock. Pyrites occurs, too, in the "vughs" to be described below. The pyrites is present in such amount and oxidises so rapidly on exposure to the air, producing dirty brown stains on the face of the rock, that the value of the rock as a building stone is very greatly lowered. Indeed it has of late been superseded by other granites brought from greater distances. In describing this rock Professor Richards states:

—"The occurrence of crystals of pyrites throughout the rock, and of cavities or 'vughs' containing calcite pyrites, &c., is a great disadvantage to this stone."[11].

These "vughs" or "druses" are peculiar to this rock and this particular outcrop, the writer never having observed them anywhere else in the area. They are of various size and occur in perfectly fresh rocks, having been found in the heart of the building-stone quarries. The minerals associated with these vughs are mostly calcite and pyrites, though quartz and prehnite are also found. These minerals are certainly not secondary in the sense that they are weathering products, but they are probably primary in origin and result from the action of mineralisers at a late stage of consolidation. They would thus be secondary only in the sense that many of the zeolites of the Tertiary basalts of Queensland are secondary. To use Sederholm's term, they are "deuteric."[11a]

Professor Richards points out that "a noteworthy feature of the stone is the comparative absence of segregations."[12] The present writer discovered small patches of fine-grained more-basic material which he at first regarded as segregations, but which microsections proved to be small zenoliths of the Grey Phase. A comparison of Plate II. No. 6 (a zenolith) with No. 5, which is described in the writer's field notes as "typical of the Grey Phase in the west and north-west of the Enoggera area," gives some idea of the close resemblance which is seen between these rocks when placed side by side on the stage of a petrographical microscope.

Of especial interest is the occurrence in both slides of rounded crystals of quartz, free from inclusions and surrounded by a rim of idiomorphic crystals of biotite arranged parallel to the outline of the quartz.

Towards the edges of the (?) Hybrid mass one finds irregular and vaguely defined patches of pink material of varying size. This zone forms in the field a connecting link between the Enoggera (?) Hybrid and the Pink Phase.

(*d*) The Rhyolitic Intrusives.

The intrusive rocks surrounding and associated with the granitic rocks fall naturally into two distinct types,

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[11] Op. cit. p. 102.

[11a] Bull. de la Comm. Geol. de Finlande No. 48, 1916, p. 142.

[12] Op. cit. p. 102.

although an occasional dyke is seen which has some points in common with each of these types. The types the author considered in Part I. of this paper under the headings "The Rhyolitic Intrusives" and "The Porphyries." More recently Mr. L. C. Ball, B.A., in his report dealing with the geology of the silver-lead deposits near Indooroopilly, included both these groups under the term "Felsites."

With his "Notes on Indooroopilly"[13] Mr. L. C. Ball, Deputy Chief Government Geologist, publishes a map of the Indooroopilly area on a considerably larger scale than that which accompanies Part I. of this paper, and showing the network of outcrops which the Rhyolitic Series form in this area in much greater detail than was done by the author. The author would like here to digress from the purely petrological point of view to discuss a structural matter of some importance.

Although Mr. Ball states that "attempts to distinguish laccolites and sills among the dykes are not warranted on the exposures," the author finds in Mr. Ball's descriptions and map several points which appear to uphold his published opinion that the intrusions of the southern area are largely laccolitic, the present outcrops being partial exposures of irregular laccolites. The author never intended to convey the idea that these laccolites were of the ideal type, which rarely has been found in the field. The closest approach to this ideal are the laccolites described by Gilbert from the Henry Mountains, Utah.[14] Gilbert himself, however, figures as an "ideal cross section of a laccolith with accompanying sheets and dykes," a series of intrusions which, on partial exposure by weathering, might very well give a quite similar outcrop to that in the neighbourhood of Indooroopilly. But the types of laccolite most closely approached in the Indooroopilly area are, in the author's opinion, those of the El Late Mountains, Colorado, described by Cross, and the so-called "Cedar-tree" compound laccolite described by Holmes from the La Plata Mountains of Colorado.[15] A good example of the less regular type of laccolite, and one which the author has had the opportunity of studying in the field, is the Gabbro

[13] Qld. Govt. Min. Journal, vol. xxi. p. 266.

[14] Report on the Geology of the Henry Mts. 1879.

[15] Harker, "Natural History of Igneous Rocks," p. 66, fig. 10.

laccolite of the Cuillins, Isle of Skye, described and figured by Harker.[16]

A glance at Mr. Ball's map shows a network of outcrops which at first are difficult to reconcile with the conception of a laccolite. This network is not, however, the outcrop of vertical and steeply dipping dykes striking in every direction. It is the result of mapping more or less continuous intrusions generally with a slight dip in a hilly locality. Mr. Ball recognises this fact and writes:—"In many of the exposures the dyke walls dip at comparatively low angles. In fact, most of the mapped loops are in reality not due to branching of the dyke mass, but to partial covering by schist islands or inliers."[17]

Away from the effect of the intrusions the Brisbane schists strike N.N.W. and dip quite steeply to the E.N.E. In discussing the Brisbane schists in the locality in question, Mr. Ball states:—"The strata have been much disturbed, notwithstanding that steep dips are exceptional here about. Even on the flat arches there has been much crenulation and puckering."

The expression "flat arches" fits in precisely with the author's view as to the laccolitic origin of these low dips.

To quote Mr. Ball further:—"The brecciation of the schists along the faults on Finney's Hill is a puzzling feature. The structure is certainly not due to compressive forces. To explain it we must assume an arching of the strata above a plutonic or hypabyssal intrusion sufficient to cause a breaking-down of the beds under the tensile stresses induced. Alternatively these stresses may have been induced in the sedimentaries by a partial retrograde movement (a sucking back, as it were) of the molten magma." The author feels sure the great majority of geologists would favour the former as being the more probable hypothesis. The arching of the strata which Mr. Ball "must assume" is the arching which I firmly believe to exist.

We have, then, found all the essential features of irregular laccolitic intrusion, with the exception of the flat bases. No evidence is available either way on this point at

[16] "The Tertiary Ingeous Rocks of Skye," Mem. Geol. Surv. U.K. 1904, 85 *et seq.*, fig. 15.

[17] Op. cit. p. 266.

the present time, but future mining operations in the area may furnish data on this matter.

To return to a consideration of the Petrology of the Rhyolitic Intrusives. The naming of the fine-grained acid intrusives was a matter to which the author gave considerable attention. In spite of their definitely intrusive character and the fact that many of them have been considerably altered by the addition of secondary silica, they appear to be petrologically more closely related to the Rhyolites than to any other rock group. Mr. Ball, in referring to rocks of this series, uses the terms "felsite" and "felsitic," which certainly reflect the mode of occurrence better than the author's term "Rhyolite" unless one is careful to qualify it by the word intrusive, but the absence of felsitic textures in the rocks examined under the microscope and, further, the fact that they can be closely correlated with the intrusive "Rhyolites" (so-called by Andrews and Saint-Smith) of New England (*see* Table II.), has led the author to retain the term "Rhyolitic Intrusives."

(*D. 12*) 171.—Dyke near junction of creeks in Portion 681, Parish of Indooroopilly. (*See* Microphotograph Plate III., No. 9.)

Megascopic.—A fine-grained greyish rock showing very small yellowish-brown felspars and small patches of pyrites set in a fine-grained grey base. A vein of quartz from 1-2 mm. across is to be seen traversing the specimen.

Microscopic.—Very fine-grained holocrystalline rock, with small vaguely defined decomposed phenocrysts of felspar (orthoclase ?) set in a ground mass made up entirely of *Quartz* and *Orthoclase*. Only part of the former mineral seems to be primary, as there is considerable evidence of secondary silicification. Pyrites occurs as fresh individual crystals of very small size and as larger aggregates.

Name.—Intrusive Rhyolite.

(*D. 64*) 415.

This specimen is of particular interest from the economic point of view. It was obtained by Mr. L. C. Ball at a depth of 130 feet in the main vertical shaft of

the Finney's Hill United Silver Mines Ltd., near Indooroopilly, and supports in a very decided manner his hypothesis that the silver-lead and other ores of this area are closely associated with rhyolitic ("felsitic") intrusions. (*See* Microphotograph Plate III., No. 10.)

Megascopic.—A fine-grained light-coloured rock evidently made up for the most part of felspathic material and quartz, and traversed by numerous veins of quartz. Part of the surface of the specimen is coated with galena, accompanied by well-shaped quartz crystals.

Microscopic.—In order to preserve the appearance of this specimen a slice was cut not through the metalliferous part, but from a chip of the rock within one centimetre of it. Curiously enough this section shows no trace whatever of any metals except a few very small crystals of pyrites. The rock is similar in all its essentials to that described above (*D. 12*), but has numerous quartz veins through it and clusters of crystals of secondary quartz.

Name.—Intrusive Rhyolite.

(*e*) The Porphyritic Series.

The members of this series are usually easily separated from those of the Rhyolitic Series, but as pointed out by the author in Part I. of this paper, one occasionally meets with dykes that appear to be intermediate between these. This is, of course, only to be expected, as the two series are almost certainly genetically related. The evidence as to the relative time of intrusion of the Rhyolitic and Porphyritic Series is, so far, not conclusive, but points to the latter series as being later than the former.

(*D. 7*) 166.

Dyke across West Ithaca Creek in eastern part of Portion 678, parish of Enoggera. (*See* Microphotograph Plate III., No. 11.)

Megascopic.—A white prophyryritic rock made up of rounded colourless phenocrysts of quartz (in which can be seen numerous inclusions of a white mineral), with smaller phenocrysts of a white felspar set in a fine-grained light-coloured ground mass.

Microscopic.—Holocrystalline, porphyritic, the proportion of phenocrysts to ground mass corresponds to the "dopatic fabric" of Iddings. The ground mass is finely microcrystalline, and made up almost entirely of quartz and felspar, often intergrown. *Quartz* occurs in two distinct generations. The phenocrysts of this mineral are all rounded and embayed. They vary from 2-5 mm. in diameter, are more or less fractured, bear signs of corrosion, and show very definite "reaction rims" just outside the crystals themselves. Comparatively large rounded inclusions (or cross-sections of very deep embayments) made up of quartz-felspar aggregates similar to that of the ground mass is a feature of these quartz phenocrysts. The felspar phenocrysts are considerably altered to muscovite and other micaceous products, with the result that some of them are indeterminate, but in some cases enough remains of the original minerals to show that both *Orthoclase* and *Plagioclase* are present. The latter shows traces of Albite twinning and appears, from measurements of extinction angles, to be an intermediate andesine. Zoning is fairly definite in some of these phenocrysts. Inclusions of apatite were observed. Ferro-magnesian minerals are but poorly developed, but fragments of *Biotite* largely altered into colourless secondary minerals and magnetite were observed. Magnetite occurs in irregular patches and idiomorphic crystals, and seems to be pseudomorphus after *Pyrites*, as some remnants of this mineral are present in the interior of the magnetite crystals. Further alteration has resulted in patches of Limonite. Other minerals present in small amount are *Apatite* and *Zircon*.

Name.—Quartz Porphyry (Granodiorite Porphyry).

(*D. 4*) 163.

Dyke on road, Constitution Hill, Taylor Range. (*See* Microphotograph Plate III., No. 12.)

Megascopic.—A holocrystalline porphyritic rock made up of numerous phenocrysts of brown felspars, showing zoning and fewer smaller phenocrysts of quartz and a dark ferro-magnesian mineral set in a fine brown ground mass.

Microscopic.—Rock very decomposed. Holocrystalline, porphyritic (sempatic fabric of Iddings). The ground mass is a very fine-grained confused aggregate of felspathic

material, quartz, and secondary minerals, resulting from the alteration of the felspars. Small patches of limonite are scattered throughout the rock. The felspar phenocrysts, which vary from 2-7 mm. in length, occur in very altered crystals, and are really pseudomorphous aggregates of muscovite and other secondary minerals. In spite of this the felspars still show idiomorphic outlines, and zoning is still recognisable (indeed the zoning is apparent in the hand specimen), and points to the felspars as *Plagioclases,* although no more exact determination is possible. In some cases these phenocrysts partly enclose chloritic clusters, which are secondary after some ferro-magnesian mineral. *Quartz* occurs as a few phenocrysts up to 2 mm. in diameter, which are very similar to those described in (*D. 7*). The ferro-magnesian constituents are represented by patches of chloritic material.

Name.—Quartz Porphyry (Granodiorite Porphyry).

IV. COMPARISON WITH ROCKS OF OTHER AREAS.

(*a*) *New England and Stanthorpe*—

In Part I. of this paper the author pointed out that the granitic and allied rocks of the Enoggera district were closely comparable with those of New England in northern New South Wales, and the contiguous masses of the Stanthorpe district in the southern part of Queensland. The age of these great intrusions was seen to be much about the same, *i.e.,* very late Palæozoic; structurally they followed the same trends, while mineralogically they were very similar.

Even more striking resemblances are discovered if the sequence of events in the different areas be compared. Table II. has been drawn up for this purpose. The order of intrusion in the New England district is that found by Andrews, while in the adjacent Stanthorpe area the sequence adopted is that of Saint-Smith. These two areas are practically continuous, so that they can be very definitely correlated. If these two columns be compared it will be found that, although the grouping and naming differ somewhat, the rock types and their order of intrusion are identical, with but one exception. The "Sphene" granite is considered by Andrews to be definitely earlier than the

"'Acid'' granite, and probably earlier than the "Basic Granites,'' while Saint-Smith thinks it is much more closely related to the "Stanthorpe'' (Acid) granite, and, indeed "may possibly be a modification of the 'Stanthorpe' granite."[18] The Enoggera sequence shown in the third column agrees more closely with Andrews's interpretation on this point, but otherwise the local sequence is remarkably close to both the New England and Stanthorpe records.

TABLE II.

New England (Andrews)[19].	Stanthorpe (Saint-Smith)[20]	Enoggera (Bryan).
Intermediate to basic dykes	Basic dykes often associated with Au., Ag., Pb. Zn., Cu.	..
Rhyolites, Q. porphyries, porphyries	Rhyolites, Q. porphyries, porphyries, also	Rhyolites with Ag., Pb., Zn., Q. porphyries, porphyries
" The Euritic Period " ..	Aplites, greisens and pegmatites; sandy granite with Sn. Wo., and Mo.	Aplites with little Mo, granophyres and pegmatites
" Coarse acid granites " ..	Coarse acid " Stanthorpe granite closely associated with porphyritic sphene granite	Pink phase proper (= Mountain Camp quartz mica diorite)
" Hornblendic, dioritic, and other basic granites "	Maryland adamellite (= Greymare granite)	Grey phase
" Blue granite "	" Blue granite "	..
"Blue and black porphyries"	..	..
"Grey felspar porphyry " ..	"Acid grey felspar porphyry "	..
	Altered dioritic rocks ..	..

Note.—The " sphene-diorite porphyry " of Andrews and the " porphyritic sphen granite " of Saint-Smith are one and the same rock. The difference in position reflect a difference of opinion of these authors.

Although the Pink Phase, the Aplitic, and the Rhyolitic and Porphyritic Intrusives had their obvious counterparts in the Stanthorpe and New England Series, the "Grey Phase'' was not so easily placed, and the author did not (in the earlier part of this work) care to venture an opinion as to the precise position it occupied in these series. Since the publication of Part I., definite evidence

[18] Op. Cit., p. 18.

[19] " New England Geology " Part IV. Petrology. Rec. Geol. Surv. N.S.W., Vol. VIII. pt. 3, p. 196 *et. seq.*

[20] " Geology and Mineral Resources of the Stanthorpe, Ballandean, and Wallangarra Districts." Qld. Geol. Surv. Pub. No. 243.

of a chemical nature has become available as the result of analyses of the "Grey Phase" and the Greymare rock. The first of these (E4) was found to resemble certain analyses of the "basic granites" very closely, and did not resemble those of any other of the Phases.

Of these "basic granites," Andrews writes:—"Striking dissimilarities in appearance is a marked feature."[21] The analyses which accompany his descriptions emphasise this feature. Of the four quoted, two are comparatively acid and have alkalies in moderate amount, the K_2O being in excess of the Na_2O. These obviously have little in common with the "Grey Phase." They seem, indeed, to be more closely related to the coarse-acid granite that immediately followed them, for Andrews remarks that the more-basic types were somewhat earlier and the remaining two analyses are of this earlier more-basic type. They are of very different rock types from the others, and possess the essential characteristics of the Grey Phase, as can be seen by their positions (N.7 and N.8) on the variation diagrams.

No analysis exists as yet of the "Maryland" granite, which, however, is considered by Mr. Card[22] to be an Adamellite. It is "a fine to medium-grained greyish-blue rock." Saint-Smith,[23] in his chapter on the "Maryland" granite refers to one other rock which he says "resembles the Maryland granite to such a marked degree in hand-specimens that it may ultimately prove to represent an outcrop of this rock." This is the "Greymare" granite which has since been analysed (S.4.) This analysis, while considerably more acid, resembles those of the "Grey Phase" on the one hand and "Basic Granites" on the other in several important particulars, particularly in the preponderance of Na_2O over K_2O.

The Grey Phase seems then to be connected indirectly (through the Greymare granites) with the Maryland Adamellite and directly with the "Basic Granites" of New England.

If chemical tests be applied it will be found that the results confirm very strongly the above correlations.

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[21] Op. Cit., p. 212.

[22] Min. Res. N.S.W. No. 14, p. 91.

[23] Op. Cit., p. 61.

Variation diagrams, Plate I., Figures 1 and 2, have been carefully prepared, which show a very definite chemical relationship between the "Pink Phase" and "Acid" granites on the one hand, and the "Gray Phase" and "Basic" granites on the other.

If reference be made to Figure 1, in which the percentage weights of K_2O and Na_2O have been plotted against that of SiO_2, it will be noticed that the "Grey Phase" of the Enoggera granite (E.4) is connected with the "Greymare" granite (S.4) on the one hand and the "Basic Granites" of New England (N.7 and N.8) on the other by variation lines which show that Na_2O is present in considerable excess of K_2O in each case. While at first glance these lines seem parallel, a closer inspection shows that there is a gradual convergence as one proceeds from the more basic to the more acid rocks. In other words, the ratio $Na_2O : K_2O$ varies inversely with the acidity. The Ballandean granite (S.3) has been linked up with these curves for obvious reasons, although Saint-Smith refers to the specimen from which the analysis was made as one type of the "Stanthorpe" granite—"a medium-grained variety from Ballandean."[24]

If these "curves" be compared with the corresponding curves joining the "Pink Phase" and the "Stanthorpe" and "Sandy" granites, some very decided differences will be observed. A very close approximation in the values of K_2O and Na_2O is apparent, the curves for these oxides interweaving and remaining close together. One would naturally expect that the "Acid" granites and "Eurites" of New England, which have been so definitely correlated with the "Stanthorpe" and "Sandy" granites respectively, would approach them so closely in chemical composition as to be readily reconciled to one variation curve for the two series. In the K_2O and Na_2O values such is not the case. The K_2O is somewhat higher in the New England rocks and the Na_2O correspondingly lower. Consequently the ratio $K_2O : Na_2O$ is very much greater than in the Stanthorpe rocks. Curiously enough, in the chain of chemical evidence connecting the Pink Phase, the acid Stanthorpe granites, and the acid granites of New England, the latter is the weaker link in spite of the fact that the former connects outcrops which are separated by approximately 100 miles.

[24] Op. Cit., p. 43.

The values of the alkalies of these New England rocks have, then, been linked up to form curves independent of the main "Pink Phase"—"Stanthorpe" curve.

Three analyses are shown in which the K_2O and Na_2O values do not readily fall on either curve. These are the "Acid" granites from Tingha, New South Wales (N.2), the "Sandy" granite of Stanthorpe (S.1), and the Enoggera Hybrid. It may be argued that any attempt to fit this "Sandy" granite into the variation diagrams was unwarranted in the first place, as it represents a later phase than the "Acid" granite. However, these two acid phases are very closely associated in the field, and the position of the New England "Euritic" granite (N.4) on the diagram partly justifies the assumption of their close relationship. However, if both the Sandy and Euritic granite be ignored there remains one rock (N.2) in a somewhat anomalous position.

In Figure 2 the values of CaO and MgO have been plotted in the same manner as the alkalies in Figure 1. In this case the same sets of curves have been drawn, but the natural grouping along three different sets is not nearly so well displayed. Indeed, one might draw one set of generalised curves to which all the values plotted might be referred.

In both figures it will be noted that the values for the Enoggera (?) Hybrid do not fall on either curve. Any attempt to include them with the Pink Phase or the Grey Phase will seriously derange either curve.

TABLE III.

THE PINK PHASE AND THE EQUIVALENT ROCKS IN STANTHORPE AND NEW ENGLAND.

—	E. 1.	S. 1.	S. 2.	S. 5.	N. 1.	N. 2.	N. 3.	N. 5.	N. 6.
SiO_2	73·52	77·15	76·19	67·24	78·14	76·28	75·78	73·98	71·27
Al_2O_3	11·05	13·45	11·53	14·20	11·89	11·41	12·42	13·47	13·40
Fe_2O_3	Nil	0·40	0·84	1·50	0·60	1·60	0·55	0·72	1·11
FeO	3·15	1·26	1·25	2·88	0·27	0·72	1·08	0·97	1·89
MgO	1·03	0·72	0·60	1·39	0·15	0·15	0·50	0·36	0·79
CaO	1·70	1·22	1·14	3·24	0·44	0·62	1·06	0·90	2·46
Na_2O	4·08	2·72	3·80	3·98	3·51	3·97	3·20	3·39	3·08
K_2O	3·99	3·76	4·14	4·07	4·62	4·54	4·60	4·88	4·91
H_2O + ...	0·44	0·20	0·28	0·50	0·32	0·40	0·44	0·32	0·32
H_2O −	0·16	0·08	Nil	0·12	0·28	0·16	0·14	0·12	0·18
CO_2	n.d.	..	..	0·06	..	..	0·01	0·04	0·03
TiO_2	0·20	..	0·09	0·65	0·06	0·20	0·29	0·54	0·24
P_2O_5	0·15	0·10	0·25	0·11	0 02	0·17	0·10	0·05	0·10
MnO	n.d.	0·32	0·16	0·06	..	..	0·07	0·03	..
Etc.	..	..	..	0·07	..	..	0·11	0·06	..
Total	99·47	101·38	100·27	100·07	..	..	100·35	99·83	..
Sp. Gr.	2·58	..	..	2·711	..	..	2·626	2·030	..
Symbol	I. 3,1.3 (4)	I. 4.2.3	I. 3(4).1.3	II. 4.2.3 (4)	I. 3(4).1.3	I. 3(4).1.3	I. 3.2.3	I. 3.1.3	I. 4.2.3
Name	Alaskose	Toscanose	Alaskose	Adamellose	Alaskose	Alaskose	Tehamose	Alaskose	Toscanose

TABLE IV.

THE GREY PHASE AND THE EQUIVALENT ROCKS IN STANTHORPE AND NEW ENGLAND.

——	E. 4.	S. 3.	S. 4.	N. 7.	N. 8.
SiO_2	61·10	74·89	69·70	55·05	50·04
Al_2O_3	19·24	15·11	17·70	14·15	18·68
Fe_2O_3	} 4·66 {	1·06	1·94	1·80	0·80
FeO		2·26	1·40	5·31	6·91
MgO	2·56	0·82	1·19	8·07	7·79
CaO	5·25	1·67	2·29	9·36	9·88
Na_2O	3·82	2·06	3·12	2·82	2·35
K_2O	1·68	0·73	1·36	0·72	0·12
H_2O +	1·31	0·50	0·47	1·46	1·74
H_2O −	0·64	0·31	0·25	0·22	0·28
CO_2	..	..	Nil	0·02	0·27
TiO_2	Det. with Al_2O_3	..	0·19	0·57	0·80
P_2O_5	..	0·27	tr.	0·06	0·16
MnO	..	0·22	tr.	0·22	0·14
Etc.	..	..	..	0·06	0·62
Total	100·26	99·90	99·61	99·89	100·58
Sp. Gr.	2·71	..	2·66	2·814	2·977
Symbol	II. 4.3.4	I. 2.2.4	I. 3.3(2).4	III. 5.3.4	III. 5 4.3
Name	Tonalose	..	Near Alsbachose	Camptonose	Auverguose

TABLE V.

ANALYSES USED IN TABLES III. AND IV. AND PLATE I, FIGURES 1 AND 2.

No.	Type.	Locality.	Reference.	Analyst.	Laboratory.
N. 1	Acid	Butchart's Reef, Tingha, New England	Ann. Rpt. Dept. Mines, N.S.W., 1907, p. 185	Not stated ..	Department of Mines, N.S.W.
N. 2	Acid	Middle Creek, Tingha, New England ..	Min. Res. N.S.W., No. 14, p. 63	H. P. White ..	Department of Mines N.S.W.
N. 3	Acid average ..	Bolivia, New England	Rec. Geol. Surv. N.S.W., vol. viii., pt. 3, p. 220	J. C. H. Mingaye	Department of Mines, N.S.W.
N. 4	Euritic	Two miles east of Tenterfield, New England	Rec. Geol. Surv., N.S.W., vol. viii., pt 3, p. 225	J. C. H. Mingaye	Department of Mines, N.S.W.
N. 5	Acid	21-mile peg, Deepwater to Bolivia, New England	Rec. Geol. Surv., N.S.W., vol. viii, pt. 3, p. 220	J. C. H. Mingaye	Department of Mines, N.S.W.
N. 6	Tingha	Tingha, New England	Min. Res., N.S.W., No. 14, p. 64	W. A. Grieg ..	Department of Mines N.S.W.
N. 7	Diorite	Near Junction Baker's Creek, Hillgrove, New England	Rec. Geol. Surv., N.S.W., vol. viii, pt. 3, p. 214	J. C. H. Mingaye	Department of Mines, N.S.W.
N. 8	Diorite	Near Murgatroyd's Tunnel, Hillgrove, New England	Rec. Geol. Surv., N.S.W., vol. viii, pt. 3, p. 216	J. C. H. Mingaye	Department of Mines, N.S.W.
S. 1	Sandy	Stanthorpe, Southern Queensland ..	Qld. Geol. Surv. Pub. 243* p. 38 ..	G. R. Patten ..	Queensland Agricultural Department.
S. 2	Stanthorpe ..	Quarry, near Stanthorpe, Southern Queensland	Qld. Geol. Surv. Pub. 243, p. 43 ..	G. R. Patten ..	Queensland Agricultural Department.
S. 3	Stanthorpe ..	Ballandean, Southern Queensland ..	Qld. Geol. Surv. Pub. 243, p. 43 ..	G. R. Patten ..	Queensland Agricultural Department
S. 4	Greymare ..	Greymare, near Warwick, Southern Queensland	Proc. Roy. Soc. Qld., vol. xxx, p. 150 ..	Miss I. Sterne ..	Geological Department, University of Queensland
S. 5	Stanthorpe ..	Amosfield, near Stanthorpe, Southern Queensland	Min. Res., N.S.W., No. 14, p. 84 ..	H. P. White ..	Department of Mines, N.S.W.
E. 1	Pink Phase ..	Portion 823-824, parish of Enoggera, near Brisbane	Ann. Rep. Ag. Chem. Qld., 1915, p 20 ..	G. R. Patten ..	Queensland Agricultural Department
E. 2	Hybrid ..	Quarry, Enoggera Creek, near Brisbane..	Proc. Roy. Soc. Q d., vol. xxx, p. 150 ..	N. H. Christensen	Queensland Agricultural Department
E. 3	Pink Phase ..	Quarry, Mountain Camp, near Brisbane..	Now first published	G. R. Patten ..	Queensland Agricultural Department
E. 4	Grey Phase ..	Included mass in Pink Phase, Enoggera, near Brisbane	Now first published	Miss E. W. Muir..	Geological Department, University of Queensland

* This analysis has evidently been confused with that on page 43 (S. 2). The correct analysis appears under S. 1.

(*b*) OTHER QUEENSLAND AREAS.

The division of the granitic rocks of the Enoggera district into two phases—the earlier typically grano-dioritic (the Grey Phase) and the later somewhat more alkaline (the Pink Phase)—seems to be reflected in all those granitic rocks of Queensland of which analyses are available. Not only is this twofold development widespread geographically; in time, too, it appears to be wonderfully persistent. As far north as Charters Towers and as far back as Early Devonian, these two distinct phases are met with.

The plutonic rock nearest to the Enoggera area, of which a chemical analysis exists, is the Mountain Camp Quartz Mica Hornblende Diorite, which lies within 3 or 4 miles of the main Enoggera outcrop (*see* analysis E.3). This rock has a handsome appearance and makes an excellent building stone. It was selected by Professor H. C. Richards as the most suitable granitic rock available for the construction of the base of the new Brisbane Town Hall. Mineralogically this rock most closely resembles the Pink Phase, although it is, of course, considerably less acid and does not carry enough pink orthoclase to give the characteristic colour. The chemical analysis gives added weight to the mineralogical evidence, for though it is remarkably like that of the Grey Phase (E.4) in most respects, in the all-important matter of the alkalies it shows its true relationship to the Pink Phase, the Na_2O being slightly in excess of the K_2O. The variation diagrams, too, point clearly to its relationship to the Pink Phase.

The remaining comparisons must necessarily be general in their nature. So little has been done in the study of the plutonic rocks of Queensland that little in the way of detailed correlation is possible.

Mr. Reid[25] has described from the Charters Towers goldfield a series of granodiorites and associated rocks of Lower Devonian or pre-Devonian age, all of which show rather low alkalies with a decided excess of Na_2O over K_2O, and which are followed by an aplitic granite which "is intrusive in the granodiorite" and the analysis of which shows high alkalies with the potash in excess of the soda.

[25] "The Charters Towers Goldfield," Qld. Geol. Surv. Pub. No. 256, p. 66.

This seems to have been followed by a reversion to a series of dykes of a dioritic and porphyritic nature, all of which show a preponderance of Na_2O over K_2O with comparatively high values for CaO.

In the East Moreton and Wide Bay districts to the north of the Enoggera area are a number of plutonic and hypabyssal rocks which have been described by Dr. H. I. Jensen,[26] and which petrologically and chemically seem to have many points in common with the Enoggera rocks. Of these the "Neurum" granite of the Woodford area seems to most nearly approach the Enoggera granites in age, since Jensen considers it to be "post-Carboniferous, probably Permian."[27] It is described as "a bluish, tonalitic granite." Referring to this granite he says further:—"The graphic granite aplites of the Delaney's Creek and Fife's Range mountains are probably the last differentiation products of this mass." This seems a fairly close parallel both of types and events with the Enoggera area.

Further, Jensen, in summarising the history of this East Moreton and Wide Bay area, refers to an original quartz dioritic rock which was closely followed by an aplitic phase; one result being the formation of "mixed" rocks referred to earlier in this paper.

V. ECONOMIC.

The decision at which the author arrived, that the Enoggera granite was probably related to the Stanthorpe and New England "acid" granites, held an economic interest in addition to its geological significance, as both these granites are stanniferous. However, so far as the author can discover, no find of tin has ever been made on this area. As noted on p. 152, Part I., of this paper, flakes of molybdenite were discovered while the field work was being carried out, and since that time molybdenite in small quantities has been found in several parts of the area.

This sparse occurrence of molybdenite and the local tourmalinisation of the granite on its north-eastern edge are the only points which suggest the possible existence of tin

[26] "Geology of Parts of the East Moreton and Wide Bay Districts. Proc. Linn. Soc. N.S.W. Part I. 1906, p. 73.

[27] Op. Cit., p. 92.

within this area, although mining for arsenic, gold, silver, copper, lead, and bismuth[28] has been carried out at the neighbouring Samford massif some few miles away.

On p. 161, Part I., Rands was quoted as having described "very minute specks of gold" in one of the dykes which form the extensive system of intrusions between the south-eastern edge of the Enoggera granite and the Brisbane River at Indooroopilly. Up to that time (November, 1914) no other minerals of economic value had been found associated with these intrusions, but in the year 1918, a discovery of silver-bearing galena was made at Finney's Hill, near Indooroopilly, associated with the "Rhyolitic" intrusions. Up to the present some 280 tons of lead and 45,753 oz. of silver have been produced from the area, while the presence of copper, zinc, and bismuth in smaller amounts has been proved. Ball has mapped the intrusives in this area in great detail, as he considers them the "sole guides in searching for new shoots of ore."[29] He states further that "a clear case is presented at Indooroopilly in favour of a magmatic derivation, the metalliferous solutions being an extreme differentiate of the plutonic igneous mass from which the felsitic dyke rocks arose—the presence of ¼ to ½ per cent. bismuth is, in my opinion, decisive evidence."

A specimen of the rhyolite ("felsite"), which actually contained silver-bearing galena, was kindly supplied by Mr. Ball, sliced and microphotographed. (*See* Plate III., No. 8.) The rock is in all respects like the other intrusive rhyolites of the neighbourhood, except that veins of secondary quartz are even more pronounced than usual.

The value of the Hybrid rock (commercially known as the "Enoggera Granite") as a building stone, and for purposes of "pitching," "kerbing," and road-making has been very fully dealt with by Professor Richards in a paper read before this Society in July, 1918.[30]

CONCLUSION.

In conclusion, I wish to thank Professor H. C. Richards, D.Sc., for the interest he has shown in this work (which was originated at his suggestion) and for his helpful advice on many points.

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[28] L. C. Ball, Qld. Govt. Min. Journ., Vol. XXI. p. 266.

[29] L. C. Ball, Qld. Govt. Min. Journ., Vol. XXI. p. 267.

[30] "The Building Stones of Queensland," Proc. Roy. Soc. Vol. xxx., p. 101 *et seq.*

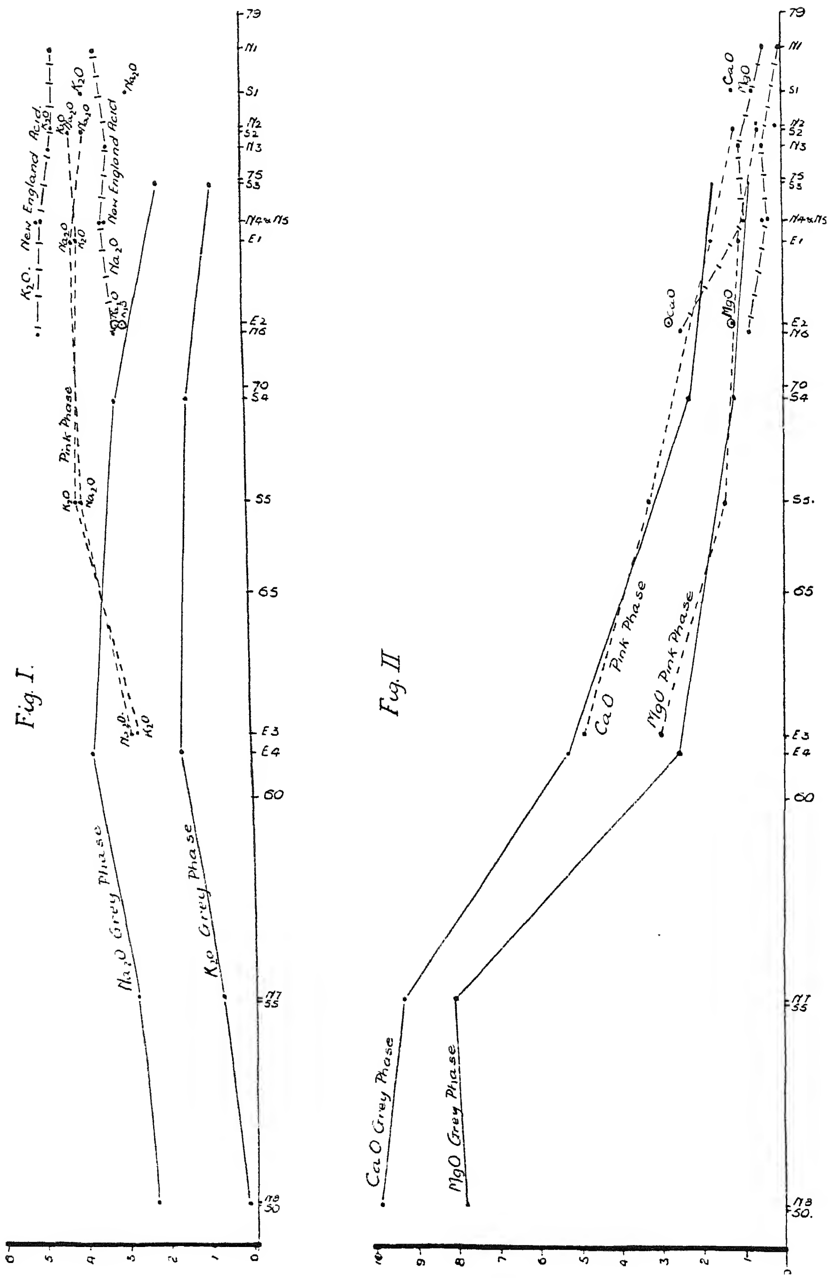
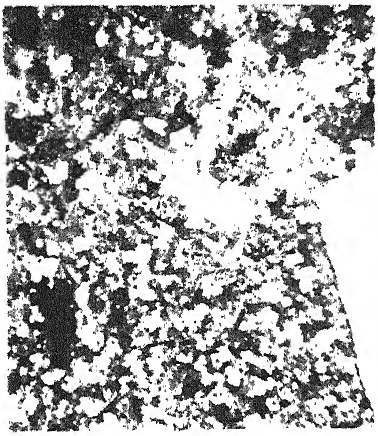


Fig. I.
K_2O New England Acid.
Na_2O New England Acid
Pink Phase
Na_2O Grey Phase
K_2O Grey Phase
Fig. II
CaO Pink Phase
MgO Pink Phase
CaO Grey Phase
MgO Grey Phase



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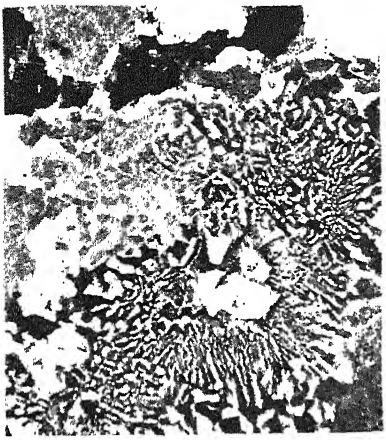
2.



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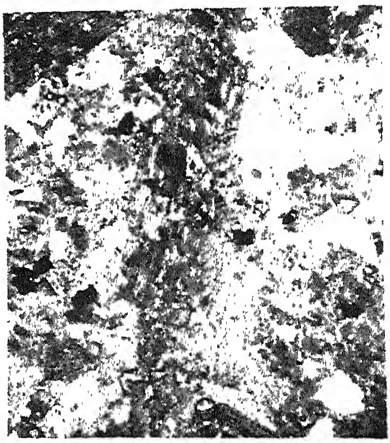


4.

5.

6.

Plate I.

VARIATION DIAGRAMS.

These have been constructed by plotting the silica percentage (on the horizontal axis) against the other oxides in percentages (on the vertical axis). The scales are the same for each axis and for each figure.

Lines joining members of the Grey Phase are shown thus:————

Lines joining members of the Pink Phase are shown thus:- - - - - - - -

Lines joining members of the New England Area are shown thus:—|—|—|—|—|

The position of the Enoggera Hydrid is shown thus :◎

The letter-numbers (E.1, S.3, N.4, &c.) refer to the analyses of Tables III., IV., and V.

Figure 1 shows the curves obtained by plotting K_2O and Na_2O against SiO_2.

Figure 2 shows the curves obtained by plotting CaO and MgO against SiO_2.

Plates II. and III.

MICROPHOTOGRAPHS.

All the microphotographs are magnified 25 diameters. No. 4, Plate II., was taken in ordinary light. All the other microphotographs were taken with crossed nicols.

Plate II.

No. 1 (G.1) 141.—Pink Phase. Specimen from southern part of main Enoggera mass, × 25, crossed nicols.

No. 2 (G.26) 422.—Pink Phase. Specimens from Green Hill area, × 25, crossed nicols.

No. 3 (G.43) 351.—Micrographic structure in Aplite, × 25, crossed nicols.

No. 4 (G.44) 416.—Grey Phase. Hornblendic type. Portion 374, parish of Enoggera, × 25, ordinary light.

No. 5 (G.41) 345.—Grey Phase. Intermediate between Hornblendic type (*see* No. 4) and Biotitic type (*see* No. 6). From near "The Summit," Taylor Range, × 25, crossed nicols.

No. 6 (G.14) 418.—Grey Phase. Biotitic type from western part of the main Enoggera area, × 25, crossed nicols.

Plate III.

No. 7 (G.6) 154.—(?) Hybrid Granodiorite from Quarry, Enoggera Creek, × 25, crossed nicols.

No. 8 (G.6) 154.—Zenolith of Biotitic type of Grey Phase in (?) Hybrid. Compare with Plate II., No. 6, × 25, crossed nicols.

No. 9 (D.12) 171.—Intrusive Rhyolite near junction of creeks in portion 681, parish of Indooroopilly, × 25, crossed nicols.

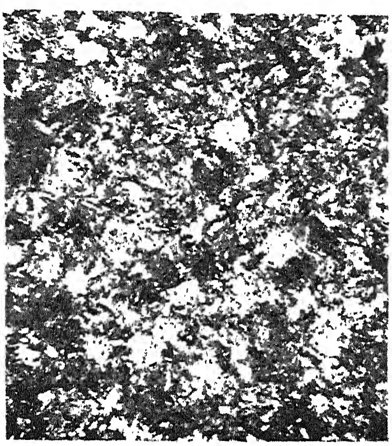
No. 10 (D.64) 415.—Intrusive Rhyolite associated with silver-lead ores, Indooroopilly, × 25, crossed nicols.

No. 11 (D.7) 166.—Porphyritic dyke across west Ithaca Creek, × 25, crossed nicols.

No. 12 (D.4) 163.—Porphyritic dyke on road, Constitution Hill, Taylor Range, × 25, crossed nicols.

7.

8.



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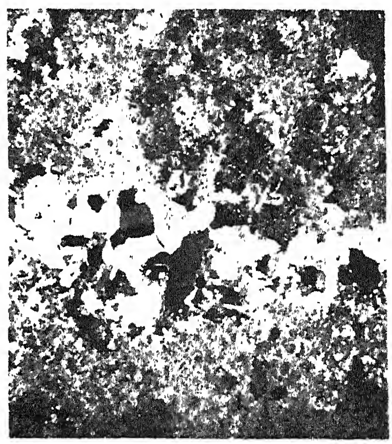

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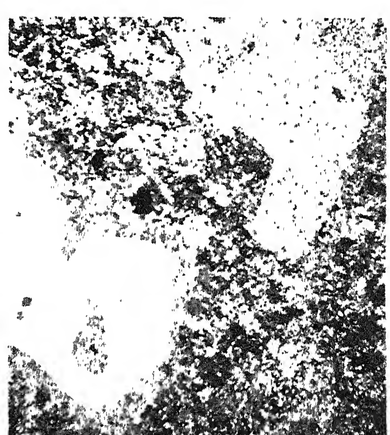

12.

Anorthoclase Basalt from Mapleton, Blackall Range, South-Eastern Queensland.

By H. C. RICHARDS, D.Sc., Professor of Geology and Mineralogy, University of Queensland.

(Plate IV.)

(*Read before the Royal Society of Queensland, 31st August, 1922.*)

SOME time ago, while investigating the volcanic rocks of the Blackall Range some 60 or 70 miles north of Brisbane, in the Mapleton area, the author was attracted by a basaltic flow which contained numerous lozenge-shaped phenocrysts of felspar. Subsequent microscopic examination bore out the prediction that they were crystals of anorthoclase felspar.

Mr. G. J. Saunders, B.E., M.Sc., who was completing his honours course in Geology at the University in 1918, kindly undertook the complete chemical analysis of the rock; and an inspection of this shows the presence of 7·02 per cent. of alkalies—an excess of nearly 3 per cent. over the combined alkalies in the average analysis of basalt as given by Daly.[1]

Although many rhyolitic and trachytic rocks with very decided alkaline characters have been described from Southern and Central Queensland by Dr. H. I. Jensen and the author, up to the present there has not been any record of a sub-basic or basic alkaline rock containing anorthoclase.

This paper, therefore, constitutes the first record in Queensland of a basic alkaline lava containing anorthoclase.

FIELD OCCURRENCE.

About 2 miles to the south-west of the township of Mapleton, in the proximity of the Mapleton Falls, where the road leaves the top of the range to descend into the

[1] R. A. Daly, "Origin of Igneous Rocks."

valley, one finds the flow in question outcropping on the road and in the paddocks on either side. The extent of the outcrop has not been determined, but it covers a considerable acreage, while the thickness is probably something more than 20 feet.

The flow forms one of the most recent of a large number which rest approximately horizontally upon the denuded surface of the Bundamba Sandstones of Upper Triassic age, and in all probability the flow was poured out in Upper Kainozoic times.

About one-half mile nearer to Mapleton than this anorthoclase basalt one finds rhyolitic rocks outcropping in a very weathered condition. In other parts of the Blackall Range, *e.g.*, near Montville and Flaxton, the upper basalts have been poured out over the rhyolite, and this is probably the relation of the different rocks at Mapleton. Immediately underlying the anorthoclase basalt flow is a considerable thickness of olivine basalt, which is well shown in the section over which passes the water at Baroon or Mapleton Falls.

The height above sea-level is approximately 1,400 feet, and both to the south and west the range falls away steeply.

Generally speaking the basalts of the Blackall Range are very much weathered, and considerable depths of soil are accumulated on the surface. This rock yields a very rich red soil, and the weathered surface has a distinctive dark-brown colour which serves as a useful indication of its weathered outcrop.

In collecting specimens, the extreme toughness of the rock is evident and in marked contrast to most of the basalts of the area. For purposes of road construction this toughness should result in a resistance to abrasion superior to that of the other basalts in the neighbourhood, and as such it has a special value.

MEGASCOPIC CHARACTERS.

In general grain-size and colour the basalt is quite normal, but the presence of numerous phenocrysts of more or less lozenge-shaped anorthoclase felspars is a characteristic feature. An occasional phenocryst, lath-shaped and

showing lamellar twinning, is seen, but anorthoclase much predominates.

The cleavage surfaces of the latter show an interference in the reflection, owing to the abundant inclusions of augite and magnetite, which are seen to better effect under the microscope.

The specific gravity is 2·725 and is rather lower than usual in the basalts of this area.

MICROSCOPIC CHARACTERS.

Section No. 266.[2]

The rock is holocrystalline, with phenocrysts of anorthoclase up to 5 mm. in length.

The ground-mass is composed of plagioclase laths up to 0·35 mm. long, augite granules averaging 0·1 mm. in diameter, and abundant small octahedral crystals of magnetite about ·03 mm. in diameter.

The fabric is porphyritic and perpatic.[3] The minerals present are anorthoclase as phenocrysts, plagioclase (acid andesine to medium andesine), augite, olivine, magnetite, and a greenish alteration product.

The anorthoclase phenocrysts, like many of the phenocrysts of plagioclase in the basalts and andesites of Upper Kainozoic age in Southern Queensland, have been much affected by the ground-mass, as the corners are rounded and a definite reaction rim has developed.

The abundance of augite and magnetite inclusions in these anorthoclase phenocrysts is a marked feature. In all cases the reaction rim is free from inclusions. (*See* Fig. 1, Plate IV.)

A definite net-like arrangement of considerable regularity characterises the inclusions, and many instances suggesting micrographic intergrowth of the augite "inclusions" and the phenocryst may be seen.

Simple twinning is common in the crystals, and in one or two cases very fine microcline twinning occurs.

The plagioclase crystals in the ground-mass furnish lath-shaped and rectangular sections.

[2] The number refers to the slide in the University of Queensland collection.

[3] J. P. Iddings, "Igneous Rocks," Vol. I., 1909, p. 199.

From the extinction angles the felspar varies from acid to medium andesine.

The augite is highly titaniferous, as it has a distinct violet tinge. The habit of the crystals varies. It may be in compact granules showing ophitic structure with the plagioclase and containing inclusions of magnetite, or else it may occur as long narrow wisps up to 1·75 mm. but still showing ophitic structure.

The most interesting occurrence of augite, however, is in the form of inclusions in the anorthoclase phenocrysts when several granules in close proximity are optically continuous, and in this way micrographic intergrowth of the felspar and augite is indicated.

Olivine in the form of clear rounded granules occurs abundantly, and it is usually associated with a greenish alteration product—possibly serpentine.

Magnetite in small octahedral crystals occurs abundantly throughout the ground-mass and as inclusions in the phenocrysts and in the augite granules.

CHEMICAL CHARACTERS.

For the purposes of comparison four other analyses are given in addition to that of the anorthoclase basalt.

The second one—that of a flow of oligoclase basalt from the summit of Spicer's Peak in the Main Range, near Cunningham's Gap—bears a striking similarity to the analysis under consideration.

The third analysis of an olivine basalt from Mount Lindsay is also of interest for comparison.

The fourth analysis carried out by Miss Rose Scott, M.Sc., in 1918, indicates the chemical character of the normal basalt which occurs along the top of the Blackall Range.

The fifth analysis is that given by R. A. Daly as the average analysis of a basalt.

It will be noted that the anorthoclase basalt has lower alumina, more iron oxides, less magnesia, considerably less lime, more soda, and twice as much potash as the ordinary sub-alkaline basalt from Montville, which is characteristic of the Blackall Range as a whole.

In comparison with the average basalt analysis, the marked deficiencies in magnesia and lime and equally marked excesses of soda and potash are the outstanding features of the anorthoclase basalt.

An examination of the norms shows a very close resemblance, especially in the felspathic content of the Mapleton and Spicer's Peak basalts. The modes of the two rocks differ considerably, also there is much difference in their textures and crystallinity.

The felspathic content of the norm of the Montville basalt is in sharp contrast with that of the Mapleton basalt. The deficiency in potash and the excess in lime of the former is made very pronounced.

CHEMICAL ANALYSES.

Rock.	Anorthoclase Basalt. Mapelton.	Oligoclase, Basalt. Spicer's Peak.	Basalt. Mount Lindsay.[4]	Basalt. Montville.	Average Basalt (R. A. Daly.)
Analyst	G. J. Saunders, B.E., M.Sc.	G. R. Patten.	G. R. Patten.	Rose Scott, M.Sc.	
SiO_2 ..	53·33	52·95	47·50	52·00	49·06
Al_2O_3 ..	14·57	15·56	14·19	18·76	15·70
Fe_2O_3 ..	4·47	2·62	1·78	1·86	5·38
FeO ..	6·67	7·29	12·15	5·84	6·37
MgO ..	3·24	2·89	5·06	4·15	6·17
CaO ..	5·76	4·92	7·47	7·31	8·95
Na_2O ..	4·40	4·46	3·85	3·75	3·11
K_2O ..	2·62	2·94	1·58	1·27	1·52
H_2O+ ..	2·09	2·18	1·59	1·06	1·62
H_2O- ..	0·98	0·75	0·33	0·80	
TiO_2 ..	1·71	1·84	3·08	1·85	1·36
P_2O_5 ..	0·83	1·15	0·79	1·24	0·45
MnO ..	n.d.	0·14	0·20	..	0·31
Total ..	100·67	99·69	99·57	99·89	100·00
Sp. Gr.	2·725	2·74	2·79	..	..

Norms.

Quartz ..	2·46	0·90	..	3·90	..
Orthoclase ..	15·46	17·24	9·45	7·78	..
Albite ..	37·20	37·73	30·39	31·44	..
Anorthite ..	12·23	13·90	16·68	28·91	..
Nepheline ..	..	..	1·14	..	..
Corundum ..	..	..	..	0·61	..
Diopside ..	9·34	3·00	13·24	..	..
Hypersthene	9·33	14·16	..	16·47	..
Olivine ..	..	..	17·43	..	..
Magnetite ..	6·50	3·71	2·55	2·78	..
Ilmenite ..	3·19	3·50	4·41	3·50	..
Apatite ..	2·02	2·69	1·68	2·69	..
Water, etc. ..	3·07	2·93	1·92	1·86	..
Total ..	100·91	99·76	98·89	99·94	..
American Class	II. 5.2.4 Akerose	II. 5.2.4 Akerose	III. 5.3.4 Campronose	II. 5.3.4 Andose	.. ..

[4] Volc. Rocks, S.E., Qld., p. 177.

DESCRIPTION OF PLATE IV.

This shows six microphotographs of the anorthoclase basalt and of the various basalts with which it has been compared. The first four microphotographs have been taken with crossed nicols, and the last two in ordinary light. In all cases the magnification was 17 times.

No. 1.—*Anorthoclase Basalt* from Mapleton, Blackall Range. Microslide No. 266. In the centre of the field there is a phenocryst of anorthoclase showing simple twinning, inclusions of augite granules, &c., and a clear zone around the margin. The groundmass is composed of plagioclase, augite, olivine, and magnetite. Crossed nicols; magnified 17 times.

No. 2.—*Anorthoclase Basalt* from Mapleton. This is another portion of the same slide, as used for No. 1, and shows much the same features. Crossed nicols; magnified 17 times.

No. 3.—*Olivine Basalt*, Mapleton Falls, Mapleton, Blackall Range. Microslide 260. This rock immediately underlies the anorthoclase basalt. It contains phenocrysts of olivine set in a groundmass of plagioclase, augite, olivine, magnetite, and a greenish glass. Crossed nicols; magnified 17 times.

No. 4.—*Basalt* from road cutting near State School, Montville, Blackall Range. Microslide 262. This slide is representative of the basalts of Blackall Range, and is composed of plagioclase, augite showing ophitic structure, olivine, magnetite, ilmenite, and a greenish-brown glass. Crossed nicols; magnified 17 times.

No. 5.—*Basalt* from 3,000-ft. level. Eastern slope of Mt. Lindsay, MacPherson Range. Microslide 221. Occasional lath-shaped crystals of plagioclase occur in the hypohyaline groundmass, which is streaked parallel to direction of flow. Ordinary light; magnified 17 times.

No. 6.—*Oligoclase Basalt* from Spicer's Peak, Main Range. Microside 116. This slide shows the very fine-grained nature of the rock. The dark patch in the centre represents a crystal of olivine. Ordinary light; magnified 17 times.

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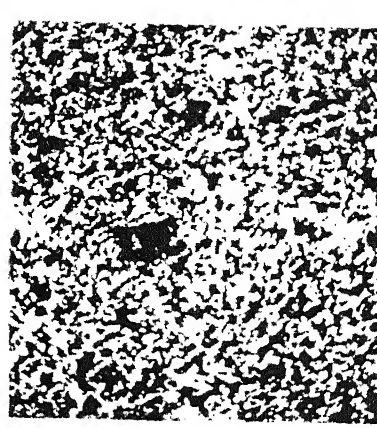

6.

Face page 166.

PETROGENIC SIGNIFICANCE.

In a previous publication[5] the author, in describing the Spicer's Peak oligoclase basalt, fully recognised its chemical difference from the ordinary sub-alkaline flows of Southern Queensland, and showed the close chemical relationship with that of the mugearites described by Harker[6] from Skye. Similar chemical characters were noted in the oligoclase basalt and the olivine basalt from Mount Lindsay, both of which terminated phases of effusion of lavas, the lower and upper basaltic series respectively, and the author wrote[7]: "Whether the occurrence of these rocks at the termination of two periods of activity during which basic rocks have been poured out is a mere coincidence or not, is a question." It is a matter of very considerable interest to find that this alkaline basalt from Mapleton, which has the same peculiar chemical characters as the basalts from Spicer's Peak and from Mount Lindsay, like them also represents the concluding effusion of a volcanic phase—the Upper Basaltic one.

One would expect the concluding effusions of each of these phases to be more differentiated than the earlier flows, owing to the law of increasing divergence, but the alkaline character of the last flow in each case has a particular interest and certainly does not support Daly's assimilation hypothesis as to the origin of alkaline rocks.

In conclusion, I extend to Miss Rose Scott, M.Sc., and Mr. G. J. Saunders, B.E., M.Sc., my thanks for carrying out, when advanced students at the University, the two analyses which have hitherto been unpublished, and which have been of the greatest help in the points considered in this paper.

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[5] "Volcanic Rocks of South-Eastern Queensland," Pr. Roy. Soc. Qld., xxvii., 1916, p. 172, p. 176.

[6] Harker, "Tertiary Igneous Rocks of Skye," p. 263.

[7] Op. Cit., p. 192.

Note on the Walloon Jurassic Flora.

By J. H. Reid.

(*Read before the Royal Society of Queensland, 31st August, 1922.*)

Until the past two years very little geological work had been devoted to the Walloon formation in Southern Queensland, and although fossil plants are abundant therein, the lack of systematic collecting and of stratigraphical data has been a serious drawback to previous palæontological work. The Flora of the Ipswich and Walloon Series has been described by Dr. Walkom on all the local material available up to 1916.[1] Since then, as the result of field work by officers of the Geological Survey, extended collecting has been possible and the material available is now much more complete.

This work comprises a reconnaissance survey of the Roma District by Dr. H. I. Jensen[2]; also a detailed survey of the Rosewood Coalfield[3] and a reconnaissance survey of the West Moreton district by the writer (in Press). No detailed work has been done in the Darling Downs area, but the omission is probably not important, since the beds there are undoubtedly continuous with the Moreton beds under a narrow strip of basalt along the Toowoomba Range, and the northern portion of the Downs is probably on the same stratigraphical horizon as some of those examined in the Moreton district. It is tolerably certain that the Walloon formation extends unbroken between Beaudesert and Roma districts, covered in places by more recent deposits. Certain important palæontological conclusions present themselves as a result of this work, which were not so obvious previously, and which connote marked differences between the Ipswich Flora and that of the Walloon, other than those noted by Walkom.

The predominant species of the Ipswich formation are the various species of *Thinnfeldia*, and the following are

[1] "Mesozoic Floras of Queensland," Pt. I. Q.G.S.P. 252 (1915), 257 and 259 (1919).

[2] Summary of report published in *Queensland Government Mining Journal*, March, 1921.

[3] Geology of Walloon-Rosewood Coalfield, *ibid*, June-September, 1921.

characteristic amongst others:—*Tæniopteris Tenison-Woodsi*, *T. Dunstani*, the large-leaved *T. Carruthersi*, *T. lentriculiforme*, and *T. Wianamattæ;* also *Cladophlebis australis*.

In the Walloon of Moreton district, *Cladophlebis australis* and, to a less degree, *Tæniopteris spatulata* are the predominant species. This holds good through a vertical section of strata probably 5,000 feet thick in the area lying between Marburg and Wilson's Peak. Both are recorded from Darling Downs and from Roma.

An important feature, however, is that no undoubted species of *Thinnfeldia* nor any of the *Tæniopteridæ*, except *T. spatulata*, were found in the Walloons of the Moreton district, nor during the detailed survey of Rosewood, where fossilferous beds are abundant, and where an intensive search for fossil evidence may be claimed to have been made.

Dr. Jensen has informed me that *C. australis* is the most abundant form in the Walloon at Roma, and that no species of *Thinnfeldia*, nor of *Tæniopteris*, other than *T. spatulata* were found in those beds. *Thinnfeldia odontopteroides* is, however, found there in Ipswich Beds underlying barren sandstones below the Walloon, but not associated with the Walloon plants. Walkom likewise does not record *Thinnfeldia*, and of the *Tæniopteridæ* only *T. spatulata*, from the Walloon of South-east Queensland, Darling Downs, and Roma.[4]

The only record of *Thinnfeldia* in the Walloon of Moreton District is *T. odontopteroides* var. *falcata*, from Rosewood Scrub, 10 miles from Ipswich, identified by Tenison-Woods[5] and included in the synonymy of *T. lancifolia* by Walkom.[6] A provisional determination by Tenison-Woods[7] of a specimen as *Gleichenia lineata* from the same locality is regarded by Walkom as a doubtful synonym of *T. acuta*, but this can be disregarded owing to the degree of doubt as to its identity. I can only assert that during the detailed survey of the Rosewood coalfield,

[4] Geology of the Lower Mesozoic Rocks of Queensland. A. B. Walkom. Proc. Linn. Soc. of N.S.W. Vol. XLIII., Pt. 1, pp. 78 and 79.

[5] Fossil Flora of the Coal Deposits of Australia. J. E. Tenison-Woods. Proc. Linn. Soc. of N.S.W. Vol. VIII., 1883.

[6] Q.G.S.P. 257, pp. 21-24.

[7] Op Cit., p. 94.

all the fossiliferous horizons detected throughout the district were collected from and no species of *Thinnfeldia* were found. Tenison-Woods, however, asserts that the species described by him is by far the most abundant form in that locality, but that position I find undoubtedly belongs to *Cladophlebis australis*, which is present in practically every specimen collected. *T. spatulata* and *Sphenopteris* sp. are also prominent.

From all this evidence emerges the following conclusions:—(1) That *Thinnfeldia*, the predominant genus of the Ipswich Beds, appears to be practically, if not absolutely, absent from the Walloon in the districts mentioned; (2) that the large-leaved *Tæniopteridæ*, as well as *T. Tenison-Woodsi* and *T. Dunstani*, similarly do not ascend into the Walloon, as far as we know, this genus being only represented (though in great abundance) so far by *T. spatulata;* and (3) the overwhelming predominance of *Cladophlebis australis* in the Walloon.

In view of the field work done, involving the examination of many hundreds of specimens from widely separated horizons, I think these conclusions can be stated with confidence; and it is to be noted that the evidence from the three areas of Moreton, Darling Downs, and Roma districts is wholly in agreement on these points, and indicates a strong palæontological break between the Ipswich Series and the Esk Series on the one hand, and the Walloon on the other. There are other differences, of course, to which Dr. Walkom has drawn attention, notably those relating to the Gingkoales, Conifers, and Cycads. While *Thinnfeldia* has not been found associated with *Tæniopteris spatulata* in the Walloon in these areas, it is, of course, known that they have been recorded together in the Clarence Series and are frequently associated in the Talbragar Beds of New South Wales.

It is also of interest that *Thinnfeldia* has not so far been recorded from the Lower Cretaceous of Maryborough or the Styx Coalfield, and that the one record of the genus from the Burrum Lower Cretaceous Series is to be regarded as a doubtful determination.[8] Its range in Queensland rocks would thus appear to be possibly much more restricted than was previously thought to be the case.

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[8] A. B. Walkom. Floras of the Burrum and Styx River Series, Q.G.S.P. 263, p. 15.

Notes on Species of Sagitta collected during a voyage from England to Australia.

By B. B. Gray, F.L.S.

(Figures 1-4.)

(*Read before the Royal Society of Queensland, 31st August, 1922*).

The *Sagitta* which are identified in this paper were collected by Doctor Moreau during a voyage from England to Australia *viâ* the Cape of Good Hope in the year 1919.

Thirteen species were obtained, three of which are regarded as new.

The method of collecting was by means of a tow-net attached to a sea tap, which was left open for an indefinite length of time.

An especial interest attaches to the material collected between Plymouth and Morocco, as in this haul twelve larval *Amphioxus* were taken.

I take this opportunity of thanking Professor T. Harvey Johnston, University, Brisbane, for his kindness in handing the specimens to me for identification.

Sagitta enflata Grassi.

Synonymy.—*S. lyra* Langerhans 1880; *S. gardineri* Doncaster 1902; *S. brachycephala* Moltschanoff 1907.

Several specimens of this species were obtained off the coast of West Africa in latitude 15° N. during August, 1919. Already recorded from the Atlantic, Indian, and Pacific Oceans between 40° N. and 40° S.

Sagitta hexaptera D'Orbigny.

Synonymy.—*S. mediterranea* Forbes 1843; *S. bipunctata* Krohn 1844; *S. tricuspidata* Kent 1870; *S magna* Langerhans 1880; *S. longidentata* Grassi 1881; *S. darwini* Grassi 1883.

Individuals of this form were obtained during the passage from St. Paul's Rocks to 122° E. longitude in September, 1919. Already recorded from the Atlantic, Indian, Pacific, and Antarctic Oceans.

Sagitta macrocephala Fowler.

One specimen of the above species was captured off the coast of West Africa in 15° N. latitude, during August, 1919, which agreed in all particulars with the type description, and in addition possessed a small spine-like projection on each papilla of the vestibular ridge, very similar to those figured by Michael (1911, Pl. III., 16, 17) for *S. gigantea* and *S. lyra*.

A few very small individuals, collected off the same coast during a run of 100 miles near the equator, I have placed, though with some hesitation, under this species, as, although all the features except the head agreed with the descriptions, the latter was very much smaller in proportion to the body than is generally the case.

Already recorded from the Atlantic and Pacific Oceans.

Sagitta minima Grassi.

This species was obtained on three occasions during the month of August, 1919—viz., during the voyages from Plymouth to Morocco, and from Madeira to the Canary Islands; off the coast of West Africa in latitude 15° N. Already recorded from the Atlantic, Indian, and Pacific Oceans.

Sagitta neglecta Aida.

SYNONYMY.—*S. septata* Doncaster 1902.

Several individuals were captured in August, 1919, during the voyage from Plymouth to Morocco. Already recorded from the Pacific and Indo-Pacific.

Sagitta pulchra Doncaster.

This species was taken off the coast of West Africa in latitude 15° N. during August, 1919. Already recorded from the Pacific and Indian Oceans and the Tasman Sea.

Sagitta robusta Doncaster.

SYNONYMY.—*S. hispida* (non Conant) Aida 1897; *S. hispida* Doncaster 1902; *S. ferox* Doncaster 1902; *S. japonica* Galzow 1910.

Specimens were obtained on three occasions during August, 1919, between Madeira and the Canary Islands;

off the coast of West Africa, in latitude 15° N.; and between Plymouth and Morocco. Already recorded from the Indian, Atlantic, and Pacific Oceans.

Sagitta regularis Aida.

SYNONYMY.—*S. bedfordii* Doncaster 1902.

Captured during the voyage from Plymouth to Morocco in August, 1919. Already recorded from the Indian and Pacific Oceans.

Sagitta setosa Langerhans.

SYNONYMY.—*S. germanica* Leuchart 1847; *S. bipunctata* Busk 1856; *S. enflata* var. Hallez 1909.

Individuals of this species were taken during August, 1919, off the coast of West Africa, in latitude 15° N. Already recorded from the North Sea.

Sagitta serratodentata Krohn.

This species was obtained in August, 1919, off the coast of West Africa, in latitude 15° N. Already recorded from the Atlantic, Indian, Pacific, and Antarctic Oceans.

Sagitta sp.

A small unidentifiable Sagitta was obtained during the run from Adelaide to Bass Straits during August, 1919.

Sagitta atlantica sp. nov.

(Fig. 1.)

A transparent but fairly firm form, somewhat resembling *S. pulchra,* but immediately distinguishable from the latter by the possession of a rayless anterior fin which is shorter than the posterior fin, and by the tip of the seizing jaw, which in *S. pulchra* has a pronounced swelling.

Length 7 mm; width 4·3 per cent. of the total length; tail length 25 per cent. of the total length.

Tail to ventral ganglion 70 per cent. of the total length.

Anterior fins 19 per cent. of total length, without rays, and reaching ventral ganglion.

Posterior fins 25 per cent. of total length; with rays

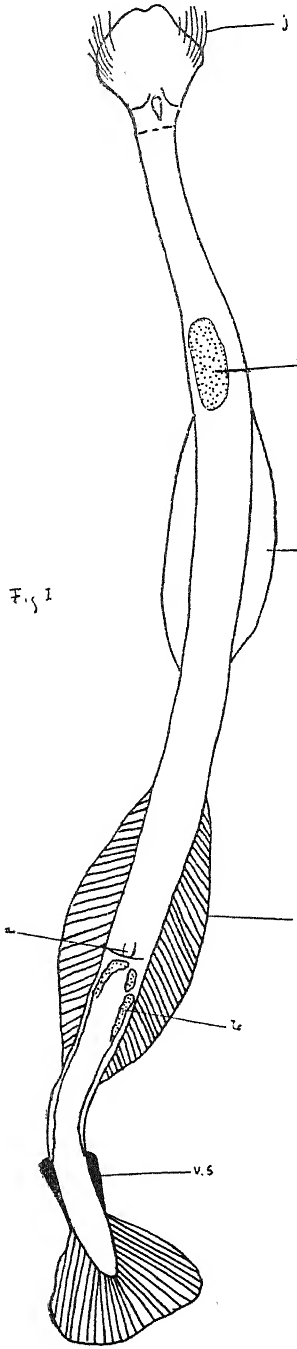

Fig I

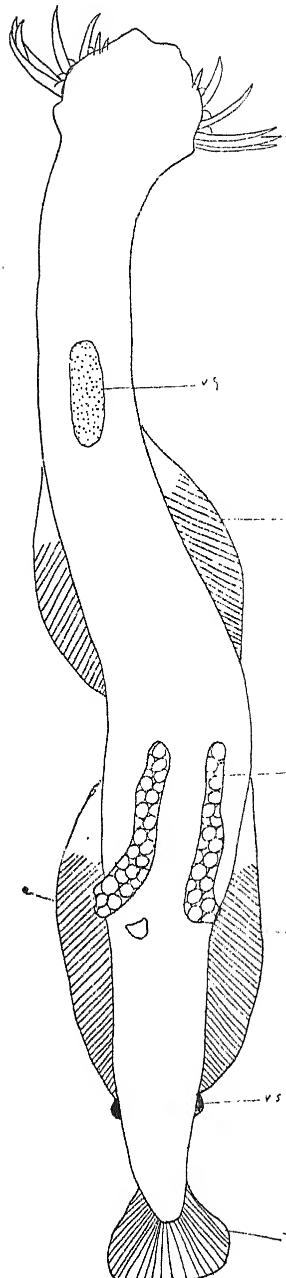

Fig II

except in a small anterior portion; 55 per cent. of the fins on the body; separated from the anterior fins by 10 per cent. of the total length of the body.

Anterior teeth 5; posterior teeth 8-9; seizing jaws 7.

Vesiculæ seminales fairly large, but not very prominent; they are touched by the tail fin, but are widely separated from the posterior fins.

Only one specimen was obtained; during the run from Madeira to the Canary Islands, on 27th August, 1919.

Sagitta equatoria sp. nov.

(Fig. 2.)

A firm opaque form with a very large head, which resembles *S. macrocephala* in this feature and in the width of the body, but is readily distinguishable by the anterior fins, which in *S. macrocephala* are only half the length of the posterior, and by the possession of twelve posterior teeth as compared to thirty-six in *S. macrocephala*.

Length 7·2 mm; width 12 per cent. of the total length; tail length 35 per cent. of the total length; tail to ventral ganglion 64·4 of the total length.

Anterior fins 19 per cent. of the total length of the body, with a rayless anterior portion, and reaching the ventral ganglion.

Posterior fins 22 per cent. of the total length of the body, with a rayless anterior portion, and reaching the vesiculæ seminales; more than 50 per cent. of the fins in front of the tail septum.

Anterior teeth 10; posterior teeth 12.

Seizing jaws 7, the tips are pointed, the shafts widely spread; vesiculæ seminales small, reached by posterior fins and separated from the tail fin; eggs few and large.

The solitary specimen from which this species is named was captured off the coast of West Africa in latitude 15° N. during August, 1919.

Sagitta moreauensis sp. nov.

(Figs. 3, 4.)

A firm semi-opaque form, which resembles *S. fridrici* and *S. bipunctata*, but differs from these in the following

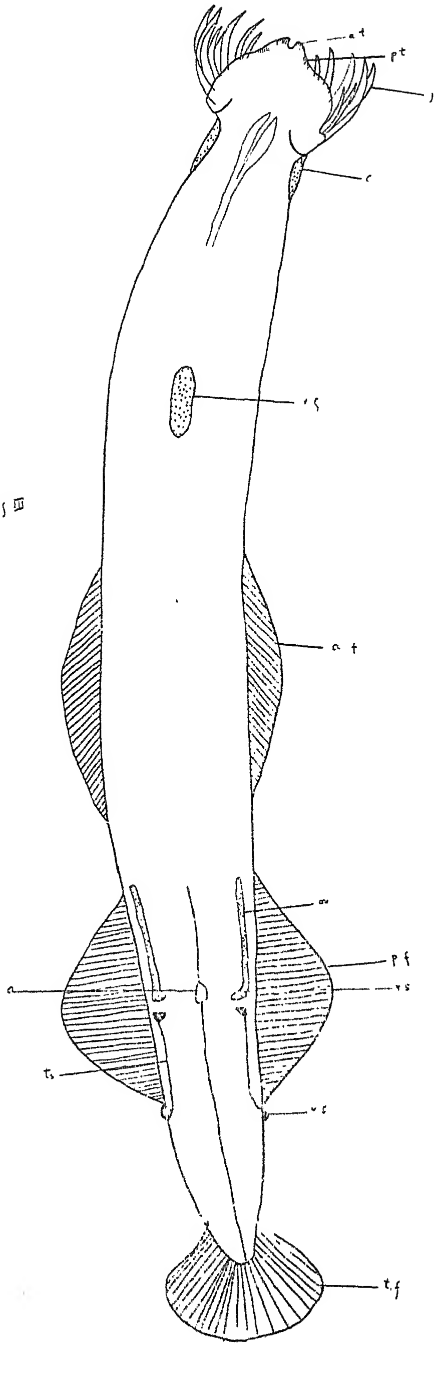

Fig III

Fig IV

particulars:—The tail fin does not reach the vesiculæ seminales in the new species, but does so in *S. bipunctata;* the posterior fins are shorter than the anterior in the former, but are longer in the latter; in *S. bipunctata* there is a distinct constriction at the tail septum, but this is not the case in *S. moreauensis*. *S. fridrici* has less than 50 per cent. of the posterior fins on the body, and the vesiculæ seminales are reached by the tail fin. These features are not similar to *S. moreauensis.*

The solitary specimen which was captured reacted in a curious way to the reagents used in staining and mounting. When the specimen was examined and measured in formalin the width was 14 per cent. of the total length, and numerous sensory papillæ were present, but after mounting the width was reduced to 5 per cent. of the total length and the sensory papillæ had disappeared. All the other measurements remained unchanged.

Length 13·8 mm; width 14 per cent.; tail length 21 per cent. of the total length; tail to ventral ganglion 67 per cent. of the total length.

Anterior fins 21 per cent. of the total length; strong, oblique rays throughout; separated by a considerable distance from the ventral ganglion.

Posterior fins 18 per cent. of the total length, with strong rays throughout at right angles to the body; separated from the anterior fins by 5 per cent. of the total length; 50 per cent. in front of the tail septum; reach the vesiculæ seminales. Collarette small; anterior teeth 6, very long; posterior teeth 8-11; seizing jaws 10-12, widely spread; the tips of the jaws are embedded in shaft for one-half their length (Fig. 4). All the jaws are not visible in the figure, as some are masked by others when the head is in this particular position.

Vesiculæ seminales very small and inconspicuous; reached by the posterior fins, but not by the tail fin. Ovary with many small eggs.

The specimen was taken between Durban and St. Paul's Rocks during September, 1919.

All drawings have been made with a camera lucida from stained and mounted specimens, and corrected for distortion, shrinkage, and damage to the fins by drawings

and measurements made in a liquid medium before staining.

Measurements are given without the fins.

TABLE OF STATIONS.

Station.	S. atlantica.	S. enflata.	S. equatoria.	S. hexaptera.	S. macrocephala.	S. minima.	S. moreauensis.	S. neglecta.	S. pulchra.	S. robusta	S. regularis	S. setosa	S. serratodentata.	S. species.	Approximate latitude.
1	..	..	..	..	..	×	..	×	..	×	×	..	..	..	50° N. to 35° N.
2	×	..	..	..	..	×	..	..	..	×	..	..	..	..	33° N. to 28° N.
3	..	×	×	..	×	×	..	..	×	×	..	×	×	..	15° N.
4	..	..	..	..	×	..	..	..	..	..	..	..	..	..	1° N. to 1° S.
5	..	..	..	..	..	..	×	..	..	..	..	..	..	..	30° S. to 38° S.
6	..	..	..	×	..	..	..	..	..	..	..	..	..	..	38° S.
7	..	..	..	..	..	..	..	..	..	..	..	..	..	×	35° S to 40° S.

1.—Plymouth to Morocco; 2.—Madeira to the Canary Islands; 3.—West Coast of Africa 15° N. latitude; 4.—West Coast of Africa 1° N. latitude to 1° S. latitude; 5.—Durban to St. Paul's Rocks; 6.—St. Paul's Rocks to 122° E. longitude; 7.—Adelaide to Bass Straits.

KEY TO THE SPECIES OF SAGITTA.

The following key to the species of *Sagitta* has as far as possible been based on those characters which are least likely to be rendered unreliable through damage during capture and subsequent treatment. In species where various authorities do not agree as to the presence or absence of any particular feature, the species is entered twice in the key, so that whichever case is correct the species may be identified.

Collarette present	13
Collarette absent	1
1. Head very large	*macrocephala*
Head normal	2
2. Tip of seizing jaw hooked	3
Tip of seizing jaw not hooked	4
3. Shaft of seizing jaw serrated	*serratodentata*
Shaft of seizing jaw not serrated	*minima*
4. Neck constriction conspicuous	5
Neck constriction not conspicuous	10

5.	Tail bilobed	*australis*
	Tail not bilobed	6
6.	Posterior teeth more than 15	7
	Posterior teeth fewer than 15	9
7.	Anterior fins with rays throughout	*elegans*
	Anterior fin with clear inner zone	8
8.	Width 8 per cent. to 12 per cent. of the total length	*enflata*
	Width 5 per cent. to 6 per cent. of the total length	*phillipini*
9.	Anterior fin reaches ganglion	*lyra*
	Anterior fin does not reach ganglion	*hexaptera*
10.	Posterior teeth more than 15	*setosa*
	Posterior teeth fewer than 15	11
11.	Tail more than 30 per cent. of the total length	*equatoria*
	Tail less than 30 per cent. of the total length	12
12.	Lateral fins confluent	*maxima*
	Lateral fins separated	*atlantica*
13.	Collarette long	14
	Collarette short	21
14.	Collarette very conspicuous	15
	Collarette not very conspicuous	18
15.	Collarette extends to vesiculæ seminales	*californica*
	Collarette does not extend to vesiculæ seminales	16
16.	Vesiculæ seminales reached by posterior fins ..	17
	Vesiculæ seminales not reached by posterior fins	*planctonis*
17.	Vesiculæ seminales reached by tail fin	*robusta*
	Vesiculæ seminales not reached by tail fin ..	*regularis*
18.	Tail more than 25 per cent. total length of body	*neglecta*
	Tail not more than 25 per cent. total length of body	19
19.	Anterior fin with rays throughout	20
	Anterior fin with clear inner zone	*enflata*
20.	Vesiculæ seminales reached by tail fin	*helenæ*
	Vesiculæ seminales not reached by tail fin ..	*elegans*
21.	Vesiculæ seminales reached by posterior fins ..	22
	Vesiculæ seminales not reached by posterior fins	27
22.	Vesiculæ seminales reached by tail fin	23
	Vesiculæ seminales not reached by tail fin ..	25
23.	Posterior teeth more than 14	24
	Posterior teeth fewer than 14	*pulchra*
24.	More than 50 per cent. of the posterior fin on body	*helenæ*
	Less than 50 per cent. of posterior fin on body	*fridrici*
25.	Tail more than 25 per cent. of total length ..	26
	Tail not more than 25 per cent. of total length	*elegans*
26.	Anterior fin longer than posterior	*neglecta*
	Anterior fin shorter than posterior	*tenuis*

27.	Width more than 7 per cent. of the total length	28
	Width less than 7 per cent. of the total length	29
28.	Opaque and firm	*moreauensis*
	Transparent and flaccid	*enflata*
29.	Seizing jaws 7 or more	*bipunctata*
	Seizing jaws never more than 7	*decipiens*

Text figures, 1-4.

Fig. 1.—*Sagitta atlantica* sp. nov. This drawing is incorrect with regard to the posterior fin, which actually has a small rayless anterior portion.

Fig. 2.—*Sagitta equatoria* sp. nov.

Fig. 3.—*Sagitta moreauensis* sp. nov.

Fig. 4.—*Sagitta moreauensis* tip of seizing jaw.

Reference to lettering: a.—Anus. a.f.—Anterior fin. a.t.—Anterior teeth. c.—Collarette. j.—Seizing jaw. ov.—Ovary. p.f.—Posterior fin. r.s.—Receptaculum seminis. s.—Shaft. t.—Tail septum. tp.—Tip of seizing jaw. ts.—Testis. v.g.—Ventral ganglion. v.s.—Vesicula seminalis.

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New and Known Australian Sarcophagid Flies.

By Professor T. Harvey Johnston, M.A., D.Sc., and O. W. Tiegs, M.Sc., formerly Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(Text-figures 1 and 2.)

As far as we are aware the whole of the literature relating to known Australian Sarcophagidæ is referred to in our two papers (1921, 1922). In the present contribution we have described a new genus and several new species, and have added additional locality records for many previously known forms.

The present paper is based mainly on specimens contained in the collections of the Queensland Museum, Brisbane, the Government Entomologist of New South Wales (Mr. W. W. Froggatt), and Dr. E. W. Ferguson, Health Department, Sydney. To these two entomologists and to Mr. H. A. Longman, Director of the Queensland Museum, we tender our thanks for the opportunity to examine the material referred to. The collection of Mr. Froggatt consisted of named and unnamed flies from various parts of Australia, and through his generosity in placing it at our disposal we have been enabled to clear up some synonymy. The abbreviations Q.M., W.W.F., and E.W.F. are used in connection with locality records to indicate the three collections respectively.

Mr. H. Hacker of the Queensland Museum has kindly assisted us by re-examining, at our request, type material of some of our previously described species.

1. Sarcophagids Recorded from Australian Grasshoppers.

The following species have been recorded as having been bred from Australian Locustidæ, viz.:—

(1) *Sarcophaga pachytyli* (Skuse) by Olliff (1891) and by Froggatt (1905) as infesting *Chortoicetes terminifera* (syn. *Pachytylus australis* Br.) from several localities in southern New South Wales;

(2) "A closely allied (if not identical) species" from the same species of locust from Richmond, New South Wales (Froggatt, 1905);
(3) *S. aurifrons* Macq. recorded by Froggatt (1905, 1907) as having been bred from the same species from Queanbeyan and Cooma, New South Wales;
(4) *S. œdipodæ* (Olliff) from *Chortoicetes terminifera*.

The first-named is more fully described in the present paper. An examination of Mr. Froggatt's collection shows that the specimens referred to under No. 2 belong to *S. peregrina;* while his material "*S. aurifrons*" from Queanbeyan belongs to *S. depressa*. In regard to No. 4, Olliff, in writing of the parasites of locusts, gave the name *Tachina œdipodæ* to a species "larger and more brightly coloured" than Skuse's *Masicera pachytyli*. This is the only description, though Froggatt in 1907 referred to the fly as a *Sarcophaga*. As we have pointed out (1922, p. 176), the name has no standing. The single specimen in Mr. Froggatt's collection was examined by us. It is not a member of the Sarcophagidæ, but has the general appearance of the Tachinid *Exorista*, though the arista is more like that of a Muscid.

2. Sarcophaga impatiens Walker.

Tambourine Mountain (S.E. Queensland)—Q.M.: North Pine (near Brisbane), Tamworth—W.W.F.

3. Sarcophaga gamma J. and T.

Brisbane, Bribie Island, Blackall Range.

4. Sarcophaga peregrina R.D.

Blackall Range, Brisbane, bred from the butterfly *Euploea corinna*—Q.M. Sydney; Kuranda (North Queensland)—E.W.F. Localities near Sydney; Gatton (Queensland)—W.W.F. Also from the locust *Chortoicetes terminifera,* from Richmond, New South Wales: the label on the pin states that the larva entered the soil on 5th March, 1904, the fly emerging on 20th March.

We may note that *S. fuscicauda* Böttcher (Entomol. Mitteilungen 1 (6), 1912, p. 168, fig 5) from Formosa is a

synonym of *S. peregrina*, whose range is now known to include Houtman's *Abrolhos* (West Australia), Sydney, Brisbane, North Queensland, New Guinea, and Formosa. It will probably be found to occur in the East Indies and Philippines.

5. Sarcophaga eta J. and T.

A number of specimens bred from the beetle *Xylotrupes australicus* Thoms., Brisbane—Q.M. There is no indication as to whether they were parasitic or merely scavengers, but were probably the latter, as we have bred the species from carrion.

6. Sarcophaga aurifrons Macq.

Amongst Mr. Froggatt's material bearing the above name were representatives of the following species:—*S. depressa*, *S. froggatti*, *S. peregrina*, *S. misera*, and *S. impatiens*.

7. Sarcophaga froggatti Taylor.

Geraldton (Western Australia); Tamworth, Merriwa, Moree (New South Wales)—W.W.F. Also a specimen collected at Darwin, Northern Territory, by Mr. G. F. Hill and forwarded to Mr. Froggatt as *S. carnaria*.

Graham-Smith in his book on "Flies and Disease—non-bloodsucking Flies" (Edit. 2, 1914, p. 35) stated that *S. carnaria* was widespread and commonly occurred in England and Australia, and was not infrequently found in houses. We do not known on what authority the statement was made regarding its presence in Australia. We have not yet recognised it. It is quite possible that some fly similar in general appearance has been mistaken for it.

8. Sarcophaga zeta J. and T.

Bulli (New South Wales)—W.W.F.

9. Sarcophaga depressa R.D.

Geraldton and Mount Magnet (Western Australia); Sydney, Warrah, Coonamble, Yarrawin, Queanbeyan, Merriwa, Lower Hawkesbury River (all New South Wales localities); Gatton (Queensland)—W.W.F. Blackheath (New South Wales)—W.E.F. This is apparently the species usually referred to in Mr. Froggatt's papers as *S. aurifrons*, the two forms being closely related.

10. Sarcophaga littoralis J. and T.

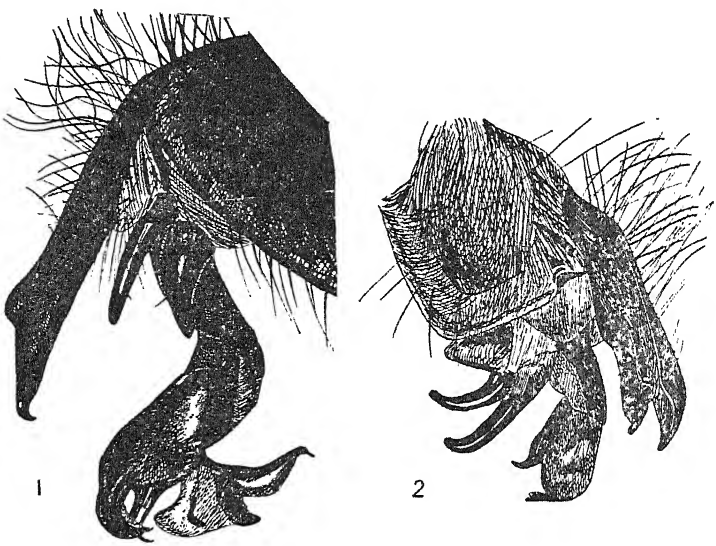
There is a specimen of this recently described species in the collection of the Queensland Museum. Locality, Tweed Heads.

11. Sarcophaga brunneopalpis n sp.

(Text fig. 1.)

Male.

In general appearance a medium-sized fly, greyish and faintly golden in colour, with the usual black markings, and measuring about 11 mm. in length. The species closely resembles *S. gamma*.



Head.—Frons not very prominent; about three-fifths the width of eye. Frontal stripe very broad, being half as wide again as parafrontals. Eyes a little over three-fifths the height of head. Parafrontals, occiput, genæ, and mesofacial plate faintly tinged with gold.

First antennal joint not very conspicuous; second fairly large and tipped with brown, third about twice the length of second. Ptilinal suture remains fairly distinct throughout life. Proboscis a deep chocolate brown, marked with black, clothed scantily with golden hairs terminally and with black hairs proximally. Palps, epistome and oral

margin brown. Vibrissæ inserted rather close to oral margin and considerably weaker than usual. Eight epistomials, and about ten facials present. A row of ten frontals beside frontal stripe; verticals well developed; lateral verticals weak. A single row of black bristles behind eyes; occiput clothed with short pale golden hairs, becoming longer below and then shortening again on the anterior part of the genæ which also bears a small number of rather short black bristles.

Thorax about a wide as head, ashy coloured and faintly tinged with gold, with the usual three longitudinal black lines, of which the middle one alone extends definitely on to scutellum; sides of thorax distinctly tinged with gold. Anterior spiracle clad with pale brown hairs. Of the anterior acrostichals only the porterior pair is distinctly differentiated; of the posterior set, only the prescutellars are present. Three humerals; three intra-alars; dorsocentral row complete. Apical scutellars present.

Legs black; femora, especially the first, faintly tinged with gold. First femur and tibia not distinctly hairy. Second femur hairy on proximo-ventral two-thirds; distally a "comb" is developed. Third femur hairy, but not very heavily; tibia hairless.

Abdomen clothed dorsally with short black reclinate bristles, but ventrally it is much less hairy than usual. Hypopygium nearly black, hairy. Forceps very dark brown; the proximal halves approximated and very hairy; the terminal third bare, slightly curved, pointed and with a hump which is obvious when the organ is seen in lateral view. Claspers brown. The penis is not unlike that of *Sarcophaga gamma* in shape; first joint whitish, with black markings posteriorly; second light brown and black, provided with several hooks and processes (fig. 1), some white, others brown in colour.

Described from one male captured by Mr. H. Hacker in Brisbane, December, 1917.

Type in Queensland Museum.

12. Sarcophaga Fergusoni n. sp.

(Text fig. 2.)

In general appearance a large broad golden insect, measuring 14 mm. in length.

Male.

Head rather broad, measuring 3½ mm. across the eyes. Height of eyes about two-thirds that of head. Front slightly over half the width of eye. Frontal stripe black, tinged with reddish brown, and measuring about twice the width of each parafrontal. Eyes red brown. Parafrontals dark golden, almost brown; occiput and genæ a beautiful brown colour. First antennal joint clearly visible, though not very large; second large, conical, nearly black; third about thrice the length of second, a brilliant brown colour, and tinged on outer border with black. Ptilinal suture lodged in a distinct depression completely surrounding the mesofacial plates and broadening out laterally, where it is coloured black. Mesofacial plate brown, with very short silvery pubescence and with borders tinged with black. About fourteen facial bristles present; vibrissæ not very large. Thirteen epistomials present. Palps a brilliant brown. Bristles on occiput golden, those clothing anterior part of genæ black. Two rows of black bristles behind eyes, of which the first is very regular, the second irregular. Verticals present; lateral verticals absent. A row of ten frontals beside frontal stripe.

Thorax about 4 mm. broad, golden, with the usual three black longitudinal stripes. Of these the middle stripe differs from that of all known Australian species in being exceedingly narrow; on either side of it occurs another longitudinal stripe rather more distinct than usual. The last two pairs of anterior acrostichals are slightly differentiated; of the posterior set, only the prescutellar pair is well developed; dorsocentral row complete; three humerals present. There is an indication of a third intra-alar.

Legs black. First femur tinged very faintly with grey, hairless; tibia slightly shorter than femur, also devoid of hair; tarsus slightly larger than tibia. Second leg hairless; femur devoid of a distinct comb. Third femur hairless; tibia hairy on its distal ventral half.

Abdomen relatively broader than usual and with usual markings; dorsal black line extends on to last segment, where it is trifurcated. Hypopygium nearly black and exceedingly small. Forceps rather straight, swollen distally and slightly hooked at termination; proximal half clothed rather scantily with a growth of long black hairs. Accessory plates not very prominent, dark brown; claspers black, simple. Penis heavily chitinised, quite black, and of a rather simple type. (Fig. 2.)

Described from a single male, collected by Dr. E. W. Ferguson, at Eccleston, Allyn River (Patterson River district), N.S.W. Type deposited in Australian Museum.

LOCUSTIVORA n. gen.

13. L. pachytyli Skuse.

Syns: Masicera pachytyli Skuse, in Olliff, Agric. Gazette, N.S.W., 1891, p. 251.

Sarcophaga pachytyli Coquillet, Insect Life, 5, 1892, p. 22.

Sarcophaga pachytyli Froggatt, Agric. Gaz., N.S.W., 16, 1905, p. 20.

Sarcophaga pachytyli Froggatt, Australian Insects, 1907, p. 315.

Sarcophaga pachtyli Johnston and Tiegs, Rec. Austr. Mus. 13 (5), 1922, p. 175.

In general appearance a rather small grey fly, 4½ to 5 mm. in length. Skuse stated that the length of the male was two lines (about 4 mm.) and the female 3 lines(about 6 mm.).

Male.

Head.—Front fairly prominent; eyes nearly four-fifths the height of head and about four and a-half times as wide as frons. Frontal stripe pale chocolate brown, nearly six times the width of parafrontals. The latter, together with the genæ and occiput, silvery, with dark reflections. Anterior portion of genæ tinged with brown. First antennal segment more conspicuous than usual; second large, brown with very faint silvery pubescence; third segment about one-third as long again as second, rather darker and with a more marked pubescence. Arista rather

longer than the three antennal joints combined; proximal third plumose. Mesofacial plates brownish, showing through the silvery pubescence. Ptilinal suture fairly distinct. Vibrissæ strong. Four facials, the upper very small. Four epistomials. Bristles on anterior part of genæ black, exceedingly well developed; succeeding bristles brown; those on lower part of occiput silvery. A single row of black bristles behind eyes; below these bristles are others irregularly arranged. A single row of ten frontals beside frontal stripe. Verticals fairly well developed. Lateral verticals present. Proboscis dark brown, palps paler brown.

Thorax considerably narrower than head. Colour a rather silvery grey, with three longitudinal lines of a brown or black colour, the median one extending farthest back and alone reaching the scutellum. The two accessory median stripes more than usually distinct. Sides and ventral surface grey. Apical scutellars very well developed. Dorsocentral row of bristles complete; anterior ones rather larger than usual. Three intra-alars. Four humerals, of which the upper is very weak, the second even weaker, the lower two strong. The last three pairs of posterior acrostichals, so far as can be made out in the material available. are present. A row of five sternopleurals above the coxa of third leg. Anterior spiracle rather small, covered with brown hairs.

Legs brown and quite devoid of hairs. The bristle rows of first femur well developed. Besides the microchaetæ the second femur possesses only a few strong bristles, especially at its extremity; "comb" absent. On the third femur the microchaetæ are equally poorly developed. The third tibia is provided with a number of abnormally large spines.

Wings.—Cell 5R almost closed. Medio-cubital nervure almost reaching margin of wing. Alulæ and wings hyaline and quite transparent. Costal nervure spiny as usual; of the others only proximal part of vein R 4 + 5 hairy.

Since the abdomen is not present in the male material available, nothing can as yet be said about the male copulatory organs.

Female.

This differs from the male in the following respects:—Frontal stripe about as wide as parafrontals. A row of eight frontals beside frontal stripe, three others outside these and converging upon them above. Thorax as in male; apical scutellars absent; scutellum not so elongated as in male and possessing an almost semicircular shape. Abdomen clothed with short black reclinate bristles and a few large ones above; hairless ventrally. General colour silvery, the black markings very restricted and indistinct. Dorsal median black stripe practically absent.

Described from five imperfect specimens obtained from "plague locusts" (*Pachytylus australis* Br. = *Chortoicetes terminifera* Walker) from the following localities in New South Wales:—Whitton, Wagga, Cooma, Corowa. (Skuse, Olliff, and Froggatt material.)

The species was briefly described by Skuse in 1891 in an article by Olliff (Agric. Gaz., N.S.W., 1891), who added figures of the entire fly, the antenna and puparium. It was subsequently stated by Coquillet (1892) and by W. W. Froggatt (1907) to be a *Sarcophaga*. To the latter author we are much indebted for the opportunity to examine Skuse's type material (from Wagga and Corowa) which is in his possession.

The characters of the species, as given in the above description, show that it cannot be placed in the genus *Sarcophaga*. We have not been able to assign it to any of the other genera belonging to the family Sarcophagidæ. We have accordingly erected for its reception the new genus *Locustivora* whose characters may be defined as follows:—

A small, but fairly robust dark grey and black species. Thorax with the usual three longitudinal lines; the accessory median lines more than usually distinct. Front in male very narrow, eyes nearly four-fifths the height of head; but in the female the frons is considerably wider than in the male. Third antennal segment only a little longer than second. Arista plumose on proximal third only. Epistomials and facials few in number. A single row of weak parafrontal bristles. Legs devoid of hair, but moderately well supplied with bristles. Cell 5R of wing almost closed. Only vein R 4 + 5 hairy. Abdomen hairless. Type, *L. pachytyli* (Skuse).

Type specimens in collection of the Government Entomologist (W. W. Froggatt), Sydney.

W. B. Gurney (Agric. Gazette, N.S.W., 1908, p. 415) mentioned having found the fly in its larval stage parasitising locusts at Tocal, near West Maitland.

When referring to the species, Mr. Froggatt (1905, p. 20) stated that two specimens of a closely allied, if not identical, species were bred from *Chortoicetes terminifera*, taken at Richmond, N.S.W. These flies were examined by us and found to be *S. peregrina*.

LITERATURE.

1921.—JOHNSTON, T. H., and TIEGS, O. W. "New and little known Sarcophagid Flies from South-eastern Queensland," Proc. Roy. Soc. Q'land, 33 (4), pp. 46-90.

1922.—JOHNSTON, T. H., and TIEGS, O. W. "Sarcophagid Flies in the Australian Museum Collection." Rec. Austn. Mus. 13 (5), p. 175-188.

A Synonymic List of Some Described Australian Calliphorine Flies.

By Professor T. HARVEY JOHNSTON, M.A., D.Sc., and G. H. HARDY, Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(*Read before the Royal Society of Queensland, 26th August*, 1922.)

NOT only have Australian blowflies been referred to under various synonyms in taxonomic papers, but also sundry combinations of generic and specific names have been utilised in designating them in works on economic entomology. The present paper is an attempt to elucidate the synonymy of those regarded as belonging to the genus *Calliphora* and its allies, and it will be noted that in addition to those previously determined, we have been able to subordinate no less than four generic and five specific names.

The excellent redescriptions of certain of Macquart's types by Surcouf (1914) have been of assistance in determining one name to be a synonym. The reasons for subordinating the others will be set forth in a paper, now in preparation, giving a detailed account of the structure and relationship of our Calliphorines.

The genera herein recognised are partly separable upon epistomal characters, since it will be noted that in some species, when seen laterally, the epistoma conspicuously protrudes at and below the vibrissa, whilst in others, viewed from the same aspect, this structure is only just visible. This character, though utilised at present by us, may not be satisfactory as gradations probably will be found when sufficient material shall have accumulated. The nature of the eyes, whether hairy or bare, is perhaps a more important character for primary separation and has been so utilised in the following key:—

1.	Eyes bare.	2.
.	Eyes hairy.	3.

2. Epistoma conspicuously protruding .. .. .. *Anastellorhina.*
   Epistoma scarcely, if at all, protruding .. .. .. *Calliphora.*
3. Epistoma scarcely, if at all, protruding .. .. .. *Neocalliphora.*

Undetermined species of Australian Calliphorine flies are known to us and these belong to the genus *Calliphora*, whilst a species identified as *Neopollenia calliphoroides* Walker, not previously recorded from Australia, may possibly necessitate a further division of *Calliphora*, under which genus it would be placed according to our key.

Ochromyia nigricornis and *O. flavipennis* Macquart, belong to the *Tachinidæ*. Surcouf placed them respectively in his genera *Prockon* and *Amphibolosia*. A female specimen of each is in our collection.

Genus **CALLIPHORA** Desvoidy 1830.

Calliphora pubescens Macquart.

C. pubescens Macquart 1850.

Genus **ANASTELLORHINA** Bigot 1885.

Syns.—*Neopollenia* Brauer 1889.
Trichocalliphora Townsend 1915.
Paracalliphora Townsend 1916.
Prockon Surcouf 1914.

Anastellorhina stygia Fabricius.

Musca stygia Fabricius 1881; Wiedemann 1830.

Calliphora stygia Schiner 1868.

Neopollenia stygia Brauer 1889; Townsend 1915; Johnston and Bancroft 1920; Johnston and Tiegs 1921, 1922; Froggatt 1922.

Pollenia stygia Cleland 1911; Johnston and Tiegs 1921 (in error for *Neopollenia*); Miller 1921.

Calliphora villosa Desvoidy 1830; Macquart 1843, 1846; Froggatt 1905, 1914, 1915, 1916; Lea 1908.

Pollenia villosa Froggatt 1917.

Trichocalliphora villosa Townsend 1915.

Musca australis Boisduval 1835.

Ochromyia lateralis Macquart 1843.

Prockon lateralis Surcouf 1914.
Pollenia rufipes Macquart 1835; Brauer 1899.
Pollenia ruficornis Macquart 1847, 1850; Brauer 1899 (? *Neopollenia*).
Musca Lœmica Walker 1849.
Anastellorhina bicolor Bigot 1885; Brauer 1898.

Anastellorhina tibialis Macquart.
Calliphora tibialis Macquart 1846.
Somomyia tibialis Brauer 1889.
Paracalliphora tibialis Townsend 1916.

Anastellorhina augur Fabricius.
Musca augur Fabricius 1775.
Anastellorhina augur Cleland 1911; Froggatt 1917; Johnston and Bancroft 1920.
Paracalliphora augur Johnston and Tiegs 1921, 1922.
Calliphora oceaniæ Desvoidy 1830; Macquart 1843; Schiner 1868; Froggatt 1905, 1914, 1915, 1916; Lea 1908.
Ochromyia lateralis Macquart 1843.
Prockon lateralis Surcouf 1914.
Calliphora rufiventris Macquart 1847.
Somomyia rufiventris Bigot 1899.
Musca dorsalis Walker 1849.

Genus **NEOCALLIPHORA** Brauer and Bergenstamm 1891.
Syn.—*Adichosia* Surcouf 1914.

Neocalliphora ochracea Schiner.
Calliphora ochracea Schiner 1868.
Neocalliphora ochracea Brauer and Bergenstamm 1891; Froggatt 1914, 1915, 1916.

Neocalliphora hyalipennis Macquart.
Ochromyia hyalipennis Macquart 1850.
Adichosia hyalipennis Surcouf 1914.

SPECIES OF UNCERTAIN GENERIC POSITION.

Musca (*Graptomyza*) *calliphoroides* Walker; a specimen from the Northern Territory, labelled "*Neopollenia calliphoroides* Walk., det. by E. E. Austen, 18.1.21, by comparison with type."

SPECIES WHOSE GENERIC AND SPECIFIC RELATIONSHIPS ARE OBSCURE.

Aureopunctata Macquart 1854 (*Calliphora*); Brauer 1899.

Clausa Macquart 1846 (*Calliphora*); Brauer 1899 (*Sonomyia*).

Disnar Macquart 1846 (*Calliphora*); Brauer 1899 (*Sonomyia-Onesia*).

Melanifera Bigot 1877 (*Somomyia*); Brauer 1899 (*Calliphora*).

Mortonensis Macquart 1854; (*Pollenia*); Brauer 1899.

Pusilla Macquart 1854 (*Calliphora*); Brauer 1899 (*Somomyia*).

Ruficornis Walker 1857 (*Musca*); Dr. E. W. Ferguson informs us that he received a letter from Dr. G. K. Marshall, Imperial Bureau of Entomology, dated 12th September, 1920, stating that this species belonged to *Calliphora*.

Rufipes Macquart 1843, 1847 (*Calliphora*); Brauer 1899 (*Neopollenia*); Townsend 1916 (*Paracalliphora*). Brauer gave *Calliphora rufipes* Macquart as a synonym of *Pollenia stygia* Fabricius. Townsend suggests the improbability of this. We consider Brauer confused Macquart's two names, *Pollenia rufipes* and *Calliphora rufipes* and therefore have substituted the former for the latter in the synonymy of *A. stygia*.

Tasmanensis Macquart 1850 (*Pollenia*).

Testaceifacies Macquart 1850 (*Calliphora*).

Viridiventris Macquart 1847 (*Pollenia*); Brauer 1899 (*? Neopollenia*).

An Unusual Rhyolite from the Blackall Range, South-Eastern Queensland.

By H. C. RICHARDS, D.Sc., Professor of Geology and Mineralogy, University of Queensland

(Plates V.-VI.)

(*Read before The Royal Society of Queensland, 30th October, 1922.*)

INTRODUCTION.

In a recent communication to this Society the author described an anorthoclase basalt—the first of its kind in Queensland—from Mapleton,[1] at the northern end of the Blackall Range in South-Eastern Queensland. The rock considered in this paper is from the same area, but is of a much rarer type and has many peculiarities, both structurally and chemically. It is a rhyolite with an extremely rich silica content and low alumina value ; it occurs near Montville, about the centre of the Blackall Range, and outcrops over an area of several square miles.

On account of its extreme values for silica and alumina and its interesting spherulitic and lithophysal characters it has a considerable intrinsic interest. Two recent scientific publications, however, give it a much wider interest.

Mr. R. Speight, M.A., in describing the rhyolites of Banks Peninsula,[2] in New Zealand, shows by analyses the character of the spherulites in comparison with the rhyolite, and accounts for the higher silica and magnesia and lower alumina of the former by the action of heated waters charged slightly with magnesian salts derived from basaltic lavas subsequently effused.

Spherulitic rhyolite, even more extreme chemically than the New Zealand one, is considered here, and the writer accounts for the pecularities by the action of heated waters and vapours accompanying the rhyolitic effusions themselves, so that the alteration and modification are not the result of ordinary atmospheric weathering, but rather due to agents of a magmatic origin coeval with the effusion of the rhyolites—the deuteric reactions of Sederholm.[3]

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[1] Proc. Roy. Soc. Qld. xxxiv., 1922.

[2] Rec. Cant. Mus. N.Z., Vol. ii., 1922, pp. 77-89.

[3] Bull. Geol. Soc. Amer., Vol. 33, 1922, p. 237.

In the "Geology of the Broken Hill District, N.S.W." by Mr. E. C. Andrews, B.A.,[4] the lack of consensus of opinion as to the origin of the so-called "quartzites" is mentioned.

It has been urged that the chemical nature of the "quartzites" is against their being regarded as originally igneous, but the writer hopes to show on the purely chemical evidence in comparison with the Montville rhyolite that it is not unreasonable to assume an original igneous nature for the quartzites.

FIELD OCCURRENCE OF THE RHYOLITE.

The Blackall Range, which has a general north and south trend and rises up to 1,500 feet or more above sea level, is situated 60 to 70 miles north of Brisbane. The range is composed of volcanic rocks of Cainozoic age resting unconformably on sandstones belonging to the Bundamba Series of (?) Upper Triassic age.

Skene's Creek, which is a tributary of the Obi Obi Creek, has its head waters on the western fall of the Blackall Range between Montville and Flaxton. After cutting its way through the basalt and andesite forming the upper portions of the Range, the creek flows in a general westerly direction into the Obi Obi Creek.

Following down the creek-bed a change from basalt to underlying rhyolite takes place in Portion 93v, Parish of Maleny, and after passing through Portion 73 into Reserve 546, there is, after two preliminary drops totalling about 80 feet, an almost sheer drop of 230 feet at the Bon Accord Falls. These falls are composed of the rhyolite under consideration.

Its field occurrence with its spherulites and fluxion structure is similar to many rhyolites of Middle Cainozoic age in Southern Queensland.

There is a wide distribution of the rhyolite as it is found in the Obi Obi Creek bed more than 2 miles south of the Bon Accord Falls, and it can be traced continuously between these points.

A thickness of at least 1,000 feet of rhyolite occurs, and may be determined by passing down into the Obi Obi Creek from Portion 132v through Portions 187 and 186.

[4] Mem. Geol. Survey N.S.W., Geology No. 8, 1922, p. 107.

Whether the rhyolite was effused from a central point or from a fissure cannot yet be stated, but there appears to have been a centre of effusion near Portion 143v in Skene's Creek, below the Falls, for we find breccia, agglomerate, and tuffaceous material of a rhyolitic nature.

GENERAL PETROGRAPHY.

There is much variation, both in colour and in structure, in the rhyolite. Fluxion and spherulitic structures are usually present, while the colour ranges from pink to grey.

Spherulites an inch in diameter occur in places, but they are nearly always altered either to kaolin or secondary silica, while often there is a kernel of silica inside a white fibrous aggregate. (See Plate V., figs. 2 and 3).

The occurrence of hollow spherulites is not uncommon, and at "The Narrows" on the Obi Obi Creek the rhyolite appears to be composed of a mass of lithophysæ showing concentric coats and hollow interiors and about 2·5 mm. in diameter. (See Plate V., fig. 1).

All the rhyolite occurrences appear to be slightly porphyritic, and both pink orthoclase showing simple twinning and about 2 mm. in length and occasional quartz crystals occur as phenocrysts.

The density of the rhyolite analysed was 2·545.

The rock, under the microscope, shows occasional lath-shaped phenocrysts of orthoclase and albite up to 1 mm. in length, set in a groundmass usually cryptocrystalline, but sometimes microcrystalline. The groundmass shows fluxion structure very frequently, while evidence of spherulitic structure is very common. Much alteration has gone on and both "secondary" quartz and kaolin occur very freely throughout the sections.

The original minerals were phenocrysts of pink orthoclase, albite, quartz, and very occasionally a ferro-magnesian mineral, possibly biotite, but invariably altered into chlorite, while in the glassy groundmass were developed rod-like aggregates of felspar.

The phenocrysts of felspar are moderately well preserved, and the extinction angle of the albite may be determined with but little trouble.

The groundmass in the rock at present appears to be made

up of kaolin and secondary quartz, some of the latter occurring as allotriomorphic grains up to ·2 mm. in length in the cavities of the hollow spherulites.

The spherulites appear originally to have been both of the compact type (with radially arranged rods of felspar) and of the hollow type (lithophysæ). The former have been altered into kaolin and are frequently stained brown by limonite, while the latter have had their cavities filled by secondary quartz. The concentric rings of rod-like material forming the hollow spherulites have also in some cases been altered to quartz, for one frequently sees optical continuity throughout an allotriomorphic piece of quartz extending from the centre across the spherulitic ring and into the surrounding original groundmass.

The glassy groundmass has been thoroughly devitrified and now consists of a cryptocrystalline aggregate in which it is difficult to resolve the separate crystals.

The groundmass of the lavender-coloured rock on the south side of Skene's Creek in Portion 143v is very deeply coloured by reddish-brown flakes and rods of iron oxide. These appear thickly studded throughout the whole rock, and the rod-like crystallites which were formed in the glassy groundmass have been either replaced or deeply stained by iron oxide. (See Plate VI., fig. 2).

Professor G. A. J. Cole,[5] in his very interesting paper in 1885 on Hollow Spherulites, etc., describes an identical occurrence in the groundmass of the rhyolite from Beaver Lake, Yellowstone Park.

PETROGRAPHIC DESCRIPTIONS OF THE VARIOUS TYPES OF RHYOLITE.

Specimen 261A.[6]

This specimen, from which the material for the chemical analysis was obtained, was collected from the bed of Skene's Creek, about 100 yards above the highest falls in Reserve 546.

Megascopic Characters.—The rock is a very fine grained pink and grey rock, showing marked fluxion structure owing to the different colour bandings. Phenocrysts of pink orthoclase occur sparingly, but small rounded brown spherulites up to 0.6 mm. in diameter are abundant. (See Plate VI., fig. 1).

The specific gravity of the rhyolite is 2·545.

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[5] Q.J.G.S. 1885, p. 165.

[6] This and succeeding numbers apply to the collections in the University of Queensland.

Microscopic Characters.—There are occasional phenocrysts of orthoclase and albite up to 0·8 mm. long occurring in a cryptocrystalline groundmass. Spherulites up to 0·6 mm. long and brown in colour are seen and have a well-defined radial structure and for the most part are regular. The felspar rods have been altered into kaolin, which is much stained by limonite. Throughout the slide there are small blotches of kaolin and limonite.

The groundmass is composed of a devitrified glass, and it is impossible to resolve it into the individual grains which one presumes to be felspar and quartz.

Here and there throughout the field there occur irregular patches of a fine quartz mosaic which strongly suggest secondary silicification.

Specimen 473 from near the top of the Bon Accord Falls.

Megascopic Characters—This is a salmon-pink in colour and is very fine grained. Occasional phenocrysts of a pink and a white felspar are noted, while the even surface of the rock shows a structure which much resembles a fine graphic intergrowth. When viewed under the microscope one sees the structure is due to the arrangement in the altered groundmass of the kaolin, which is stained pink, and of the clearer secondary quartz granules which have developed in the cavities of the small hollow spherulites of which the rock was composed.

Microscopic Characters.—This rock section differs from the one described above (261A), owing to the possession of small oval and rounded patches of secondary quartz surrounded by thin circular shells which once represented walls of hollow spherulites or lithophysæ. (See Plate VI., fig. 3).

The rod-like aggregates of felspar and quartz which constituted the rock mass have undergone alteration, so that the felspar is either altered to kaolin or is replaced by secondary quartz.

The diameter of the spherulites appears to average about 0·4 mm., but there is much irregularity about the shape and the sizes as they range down to less than 0·1 mm. and up to 0·6 mm. in diameter.

The old walls of the spherulites show a rodded structure and are about 0·05 mm. thick. The walls are now mostly kaolin in nature, but frequently one sees secondary quartz granules optically continuous from the inside right across the walls to the o' mass material outside. The spherulites

appear to have been originally hollow and the spaces have been filled with secondary quartz. As the original groundmass area has a pinkish staining through the kaolin and the secondary quartz is clear, the juxtaposition of these materials gives an appearance in the hand specimen somewhat resembling micrographic structure The size of the granules of "secondary" quartz range up to 0 2 mm. long and is more than one might expect in such a fine-grained rock. The size is no doubt due in part to the size of the openings available in the hollow spherulites.

Specimen 264.

This comes from the south side of Skene's Creek, in Portion 143v, Parish of Maleny, and about ½ mile west of the Bon Accord Falls. It differs in appearance from most of the rhyolite and yields a chocolate-coloured soil.

Megascopic Characters.—The rock is a deep lavender colour and very fine grained. Small phenocrysts of a light-coloured felspar occur sparingly through the rock.

Microscopic Characters.—Phenocrysts of orthoclase, slightly cloudy, lath-shaped, and ranging up to 0·35 mm. in length and of quartz granules generally allotriomorphic, clear and ranging up to 0·3 mm. in diameter, occur set in a groundmass of a rather unusual type. (See Plate VI., fig. 2).

The groundmass is largely glassy, while through it are abundant acicular crystals of felspar, and both granules and rods of a reddish-brown iron oxide, which from its colour by reflected light appears to be hæmatite. As mentioned above, many of the rod-like crystallites which have been formed in the cooling glass appear to have been stained or replaced by this material in the same manner as those recorded by G. A. J. Cole for a rhyolite from Beaver Lake, Yellowstone Park.

The abundance of this iron oxide is rather surprising, and one finds difficulty in accounting for its concentration in this particular portion of the magma. In a basalt from Bundamba, near Ipswich, one finds the glassy base which occurs to a small amount thickly studded with black granules and rods of magnetite and perhaps ilmenite. This rhyolite, however, is almost entirely glassy, and the rods and granules, while similar in occurrence, are more like hæmatite. There appears to be a good deal of "secondary" quartz throughout the groundmass.

Specimen 475.

This comes from Portion 183, Parish of Maleny, and is about $1\frac{1}{2}$ miles south of the Bon Accord Falls and on the other side of a basalt-capped ridge. There is little doubt that the rhyolite is continuous beneath the basalt capping, as it can be traced continuously around the end of the ridge from one point to the other.

Megascopic Characters.—It is a compact rhyolite much like 261A except that it does not show fluxion and spherulitic structures.

Microscopic Characters.—The rock has small phenocrysts of orthoclase and quartz set in a cryptocrystalline groundmass through which there is arranged much "secondary" quartz in the form of allotriomorphic granules.

Specimen 265.

This was obtained from the bed of the Obi Obi Creek, at "The Narrows," where the bed of the stream has cut a narrow canyon through the massive rhyolite flows. "The Narrows" occur at the south end of Portion 183, Parish of Maleny, and of Reserve 594, and are distant nearly 2 miles south of the Bon Accord Falls.

Megascopic Characters.—The rock is composed of spherulites, most of which are hollow and merit the term of "lithophysæ." Successive concentric rings around the hollows are visible in many of the spherulites. In size they average approximately 2·5 mm. The colour is pink to grey, and through the rock one sees occasional pink orthoclase phenocrysts.

Microscopic Characters.—The rock appears to be very much altered and to be composed of kaolin and secondary silica. The spherulites have been filled up with secondary silica, and the rods forming the concentric layers have been altered into kaolin. This rock is probably much of the same type as Specimen 473, except that the hollow spherulites were much smaller in the latter rock.

CHEMICAL CHARACTERS.

An examination of the complete chemical analysis reveals the somewhat remarkable character of the rock, and perhaps the very low alumina percentage (5·43) is even more surprising than the very high silica. The lime, magnesia, and total iron oxide percentages are very similar to those in the analyses of the average rhyolite and of the typical Southern Queensland

rhyolites. It is then in the alkalies, alumina, and silica that one sees departures from the normal.

A perusal of the analyses in Professional Paper 99 of the U.S. Geol. Survey, by Dr. H. S. Washington, fails to furnish a lava flow which is so rich in silica as the rhyolite under consideration. The nearest approach to it is a metarhyolite described by J. S. Diller from Bully Hill Mine, California, but this latter rock is nearly 4 per cent. poorer in silica and 3.6 per cent. richer in alumina, and by its relative richness in magnesia and poverty in lime and alkalies indicates much more alteration than the Montville rhyolite.

A particularly interesting analysis for comparison is that of a spheroid from a pyromeride[7] from Wuenheim, in the Vosges. The analysis is given by Delesse in the Bull. Geol. Soc. France, and used by G. J. Cole in his valuable paper on the "Alteration of Coarsely Spherulitic Rocks" in the Q.J.G.S. in 1886, p. 189. The analysis is incomplete and the alkalies have been obtained by difference, so not much reliability may be placed on that value. The silica, however, is extremely high and the alumina very low, and Cole states, on p. 189, "The silica percentage has again, however, been probably raised by the removal of bases in solution."

In a recent publication on the "Rhyolites of Banks Peninsula," New Zealand,[8] Mr. R. Speight publishes an interesting analysis of a selected spherulite from the rhyolite on Quail Island, in Lyttleton Harbour. This analysis is given for purposes of comparison, and one notes that it is poorer in silica and much richer in alumina and magnesia than the rhyolite under consideration. The alkalies, too, are very much lower, especially the soda.

Mr. Speight, in comparing the analysis of the selected spherulite with that of the spherulitic rhyolite itself, states on page 82 "that of the spherulite shows traces of the effect of some agent, which has increased substantially the quantity of silica and magnesia, has increased slightly the amount of lime, and reduced materially the alkalies and the alumina. This has, in all probability, been effected by hot water, probably charged slightly with magnesian salts, the source of which it is tempting to assign to the basaltic lavas which subsequently to the rhyolitic eruptions inundated the locality."

[7] A quartz-felsite or devitrified rhyolite characterised by conspicuous spherulitic or lithophysal structure, and thus having a nodular appearance. Nomenclature of Petrology by Arthur Holmes, p. 192.

[8] R. Speight. Rec. Cant. Mus. Vol. ii., 1922, pp. 77-89.

If one compares the Montville analysis with either the average rhyolite analysis given by R. A. Daly or with the several analyses of Southern Queensland rhyolites,[9] of which the one from Springbrook Plateau is typical, it will be seen that the variation lies in the silica, alumina, and alkalies.

There is undoubted evidence of "secondary" silica in the Montville rhyolite, and even if the silica percentage were increased 10 per cent. by its introduction one finds difficulty to account for the very low alumina. What removed the alumina ? In what form was it removed ?

The alkalies are much lower than in the ordinary rhyolites of Southern Queensland, particularly in respect to the potash. Delesse[10] insisted "strongly on the connexion between an excessive proportion of silica and the development of 'globular' or coarse spherulitic structure," and it is interesting to note that much of the Montville rhyolite is composed almost entirely of spherulites and many of them are decidedly coarse.

The norm of the rhyolite shows 27·30 per cent. of felspar, of which approximately two-thirds is albite and one-third orthoclase, while there is very little anorthite and no corundum. The norm of the spherulite from Quail Is., Lyttleton Harbour, has 17·04 per cent. only of felspar, of which anorthite is the most abundant, but in addition the norm shows 6·12 per cent. of corundum.

The paucity of the alkalies in the latter rock accounts for the difference in the felspar content and the need for forming corundum in the norm, so that one might assume that the Montville rhyolite has not been so much affected by loss of alkalies.

The Montville rhyolite is almost certainly Middle Cainozoic in age and is certainly post-Triassic, so that, although of the pyromeride type, it cannot be regarded as an ancient rhyolite. It shows devitrification to a certain extent, its felspars especially in many of the spherulites and lithophysæ have been kaolinised, and "secondary" silica occurs abundantly in much of the rhyolite.

Mr. Speight has regarded hot water charged slightly with magnesian salts as the agent causing the alteration in the spherulite from Quail Island, and assigns the origin of the water to the basaltic lavas poured out subsequently.

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[9] H. C. Richards, Proc. Roy. Soc. Qld. xxvii., 1916, p. 142.

[10] Mémoires de la Soc. Géol de France. 2 me série, tome iv., pp. 325., etc. Q.J.G.S. xlii., p. 188.

Chemical Analyses of Rhyolites, etc.

	Rhyolite Bon Accord Falls, Montville, Queensland.	Spheroid from Pyromeride, Vosges Mountains.	Spherulite from Rhyolite, Banks Pen., New Zealand.	Metarhyolite Bully Hill Mine, California, U.S.A.	"Quartzite," Municipal Quarry, Broken Hill, N.S.W.	"Quartzite" M.L. 38, Central Extended, Broken Hill, N.S.W.	Average Analysis of Liparites, and Rhyolites, after R. A. Daly.	Rhyolite, Springbrook Plateau, Southern Queensland.
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
SiO_2	85·13	88·09	82·04	81·25	84·52	86·60	72·60	73·10
Al_2O_3	5·43	6·03	10·61	9·03	5·93	5·85	13·88	13·09
Fe_2O_3	0·48	0·58	1·26	0·63	1·00	2·96	1·43	1·19
FeO	2·72		0·36	0·40	2·88	0·07	0·82	1·43
MgO	0·37	1·65	2·04	2·48	0·68	0·15	0·38	0·43
CaO	1·04	0·28	1·44	tr.	1·50	2·00	1·32	0·87
Na_2O	2·05	2·53 (by diff.)	0·40	0·25	1·31	0·66	3·54	4·03
K_2O	1·54		1·09	1·82	1·28	0·82	4·03	4·92
H_2O + ...	0·50	0·84	0·80	2·81	0·68	0·20	1·52	0·54
H_2O −	0·32		0·46	1·09	0·10	0·22		Nil.
CO_2	..	..	..	..	0·04	..	0·06	..
TiO_2	0·19	..	0·05	0·08	0·24	0·20	0·30	0·39
P_2O_5	0·17	..	..	tr.	0·05	..	..	0·11
MnO	0·02	..	..	tr.	0·03	0·19	0·12	Nil.
SO_3	tr.	..	..	S. 0·35	..	..	..	..
BaO	..	..	..	0·05	..	..	..	..
Total	99·96	100·00	100·55	100·24	100·24	99·92	100·00	100·10
Specific Gravity	2·545	2·59	..	..	..	2·70	..	2·38

NORMS.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Quartz	63·78	..	69·36	68·82	66·24	74·82	33·36	28·56
Orthoclase	8·90	..	6·67	11·12	7·78	5·00	23·91	28·91
Albite	17·29	..	3·14	2·10	11·00	5·76	29·87	34.06
Anorthite	1·11	..	7·23	..	6·39	10·01	6·12	3·06
Corundum	..	..	6·12	6·53	..	0·20	1·43	..
Diopside	2·88	..	..	..	..	..	..	..
Hypersthene	3·77	..	5·10	6·33	5·92	0·40	1·00	2·02
Magnetite	0·70	..	0·93	0·93	1·39	0·23	2·09	1·86
Ilmenite	0·30	..	0·15	0·15	0·46	0·46	0·61	0·76
Haematite	..	..	0·64	..	..	2·88	..	..
Apatite	0·34	..	..	..	0·34	..	..	0·34
Calcite	..	..	..	..	0·10	..	0·10	..
Water, etc.	0·82	..	1·16	3·90	0·78	0·42	1·52	0·54
Total	99·89	..	100·50	99·88	100·40	100·18	100·01	100·11
C.I.P.W. Classification ..	I. 2.1.4	..	I. 2(2).3.2	I. 2.1.2	I. 2(2).3.3(4)	I. 2.4.3	I. (3)4.2.4	I. 4(3).1.3

I. Rhyolite, Bon Accord Falls, Montville, Blackall Range, Queensland. Analyst: G. R. Patten, Agric. Chem. Lab. Brisbane.

II. Spheroid from Pyromeride, Wuenheim, Vosges. Q.J.G.S. xlii., p. 189.

III. Spherulite from Rhyolite, Quail I., Lyttleton Harbour, New Zealand. R. Speight. Rec. Cant. Museum Vol. ii. 1922, p. 82.

IV. Metarhyolite, Bully Hill Mine, Shasta County, California. U.S.G.S. Prof. Paper 99, p. 51.

V. "Quartzite," Municipal Quarry, Broken Hill, N.S.W. Mem. Geol. Surv. N.S.W. No. 8, 1922, p. 315.

VI. "Quartzite," M.L. 38. Central Extended, Broken Hill, N.S.W. Mem. Geol. Surv. N.S.W. No. 8, 1922, p.371.

VII. Average Liparite and Rhyolite Analysis. R. A. Daly, Igneous Rocks, 1914, p. 19.

VIII. Rhyolite. Springbrook Plateau, Southern Queensland. Proc. Roy. Soc. Qld., xxvii., p. 143. Analyst: G. R. Patten, Agric. Chem. Laby., Brisbane.

At Montville there have been andesitic and basaltic outpourings subsequent to the effusion of the rhyolite, but while one is inclined to assign the cause of much of the alteration and silicification of the rhyolite to heated waters and vapours, there does not seem to be any need, especially in this case where the magnesia content is not increased, to invoke the succeeding basic flows as the source.

It is believed (*a*) that heated waters containing silica in solution and also carbonic acid gas and other constituents have been responsible for the alteration and " weathering " of the rhyolite, (*b*) that this has gone on in the last stages of the cooling down of the lavas, and (*c*) that the source of these agents is magmatic and not atmospheric.

Dr. Harker[11] has stated that there is every reason to believe that in the tertiary basalts of the British area many minerals, such as various zeolites with chloritic minerals, etc., have been formed from the partial decomposition of minerals in basalt as a result of water and gases of magmatic origin, while J. J. Sederholm[12] has given the term " deuteric " to those reactions of the very closing stages of crystallisation and dependent on the mineralisers or " juice."

Deuteric action of this type is therefore regarded as the cause of the peculiar chemical and mineralogical composition of the Montville rhyolite.

COMPARISON OF THE CHEMICAL CHARACTERS OF THE RHYOLITE WITH THOSE OF THE BROKEN HILL " QUARTZITES."

In view of the difference of opinion[13] as to the origin of the Broken Hill " quartzites," the chemical analysis of this rhyolite has much interest. These rocks have been studied at much length by Mr. E. C. Andrews, Dr. W. R. Browne, and Dr. F. L. Stillwell. The two latter, who are highly skilled petrologists, have made special petrological studies of these metamorphic rocks in the field and laboratory, and while Dr. Stillwell advocates a sedimentary origin, Dr. Browne prefers an igneous origin.

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[11] Nat. Hist. of Igneous Rocks, p. 308.

[12] J. F. Kemp, Bull. Geol. Soc. Amer., Vol. 33, 1922, p. 237.

[13] Geology of the Broken Hill District. Mem. Geol. Surv. N.S.W Geology No. 8, 1922, p. 107.

The chemical composition of the quartzites has been regarded by some as being against an igneous origin, especially on account of the high silica, low alumina, and low alkalies.

If one compares the two analyses of the quartzites with that of the rhyolite, the only respect in which they differ is in the lime and alkali content; but in one case—that of the quartzite from the Municipal Quarry—there is really very little difference at all.

A comparison of the norms of the rhyolite and this latter quartzite is very interesting.

Mineral.	Montville Rhyolite.		Broken Hill Quartzite.	
	per cent.		per cent.	
Quartz	63·78		66·24	
Orthoclase	8·90		7·78	
Albite	17·29	18·40	11·00	17·39
Anorthite	1·11		6·39	
Diopside	2·88	6·65	..	5·92
Hypersthene	3·77		5·92	
Magnetite	0·70		1·39	
Ilmenite	0·30		0·46	
Apatite	0·34		0·34	
Calcite	..		0·10	
Water, etc.	0·82		0·78	
Total	99·89		100·40	

The quartz, orthoclase, albite-anorthite, diopside-hypersthene, ilmenite, and apatite percentages are very similar. The rhyolite has almost all of its albite-anorthite material as the soda felspar, while in the quartzite the lime felspar is relatively more abundant.

The norm of the quartzite selected—from the Municipal Quarry—is much closer to the rhyolite than the other quartzite quoted in the analyses, but at least one may say that it is not unreasonable on the evidence of the analyses to postulate an orignial igneous origin for the Broken Hill quartzites.

In conclusion, I would like to express my best thanks and appreciation to Mr. J. C. Brünnich, F.C.S. (the Agricultural Chemist, Brisbane), for granting facilities for obtaining the chemical analysis of the rhyolite, and particularly to Mr. G. R. Patten for carrying out the same.

Description of Plate V.

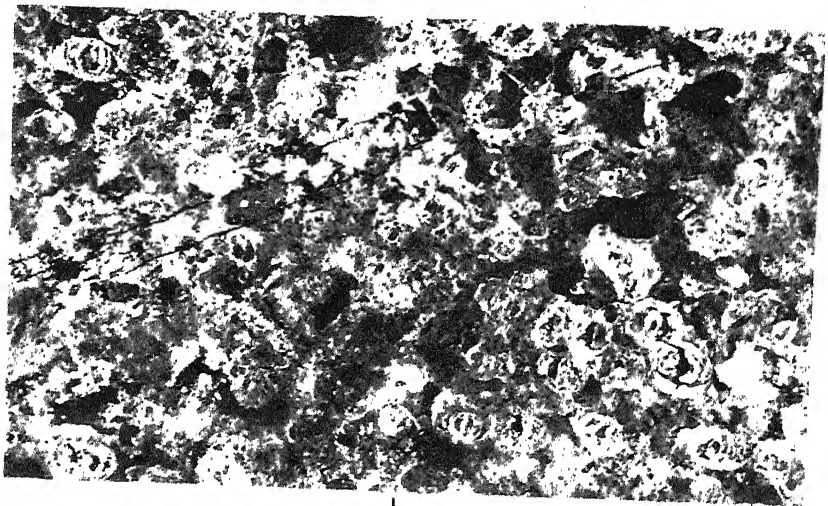
Plate V. shows four photographs of hand specimens of the Montville rhyolite. The first three are mangified $\times$ 2 and the fourth $\times \frac{10}{16}$.

Fig. 1.—*Rhyolite* from the Narrows, Obi Obi Creek, showing the lithophysæ with their hollow rounded form and concentric coats. Magnified $\times$ 2.

Fig. 2.—*Rhyolite* from Bon Accord Falls. It shows the spherulites light in colour in a cryptocrystalline groundmass. Phenocrysts of pink orthoclase occur through the rock sometimes as a nucleus to the spherulite. Magnified $\times$ 2.

Fig. 3.—*Rhyolite* from The Narrows, Obi Obi Creek, showing very well the spherulitic structure and containing much more "secondary" quartz than most of the rhyolites. Magnified $\times$ 2.

Fig. 4.—*Rhyolite* from Bon Accord Falls, showing the fluxion structure. Magnified $\times \frac{10}{16}$.



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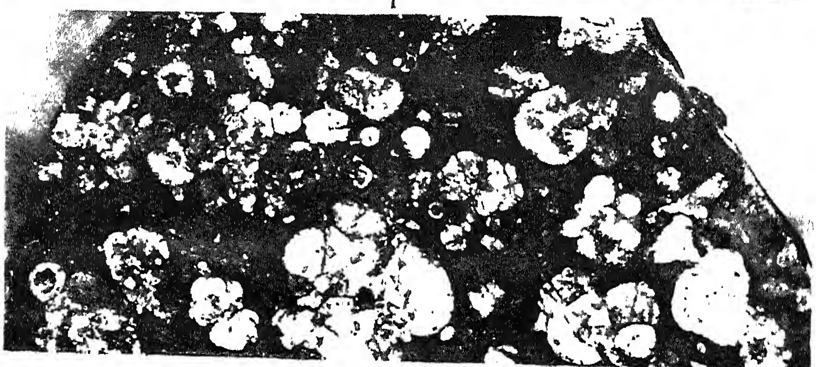

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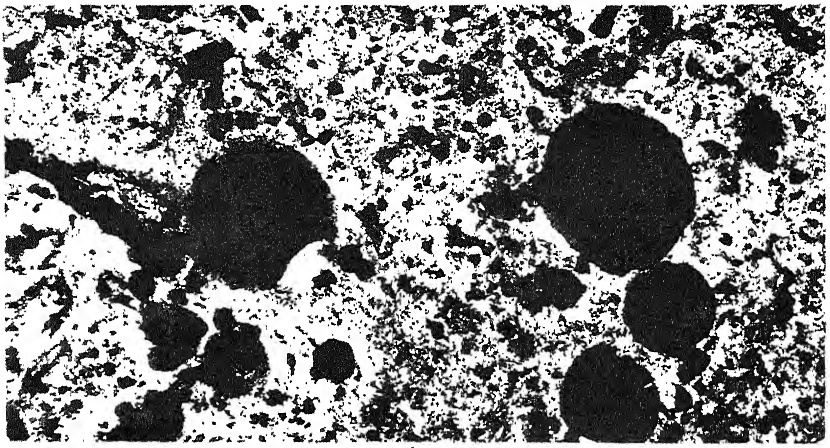
DESCRIPTION OF PLATE VI.

Plate VI. shows three microphotographs of the Montville rhyolite in ordinary light.

Fig. 1.—*Rhyolite* in microslide 261A, from Bon Accord Falls. It shows the spherulitic structure very well, also the very fine cryptocrystalline groundmass. The spherulites have a radial structure, and are composed of kaolin much stained with limonite. Ordinary light. Magnified × 50.

Fig. 2.—*Rhyolite* in microslide 264, from Skene's Creek, ¼-mile below the Bon Accord Falls. This shows the small rods and granules of hæmatite which occur so abundantly throughout the hypohyaline groundmass. The white patches represent felspar fragments and holes. Ordinary light. Magnified × 35.

Fig. 3.—*Rhyolite* in microslide 473 from Bon Accord Falls. It shows the oval to rounded character of the hollow spherulites, the thin walls of which show a radial arrangement of rod-like forms and the interior a nucleus of "secondary" quartz. Ordinary light. Magnified × 50.



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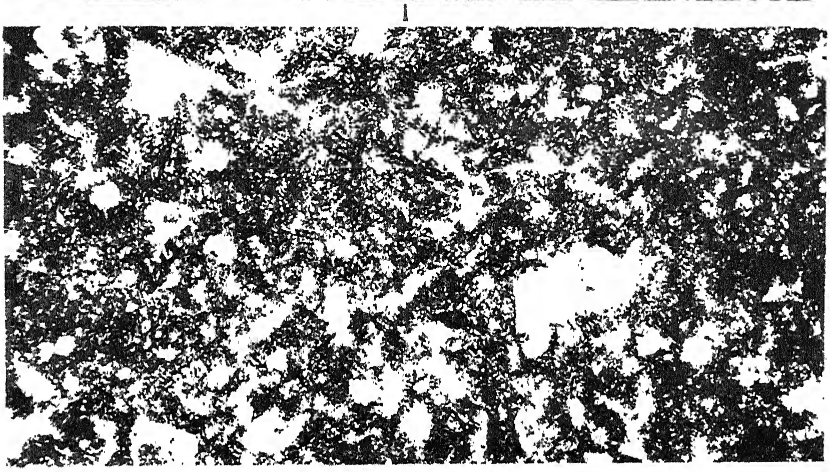

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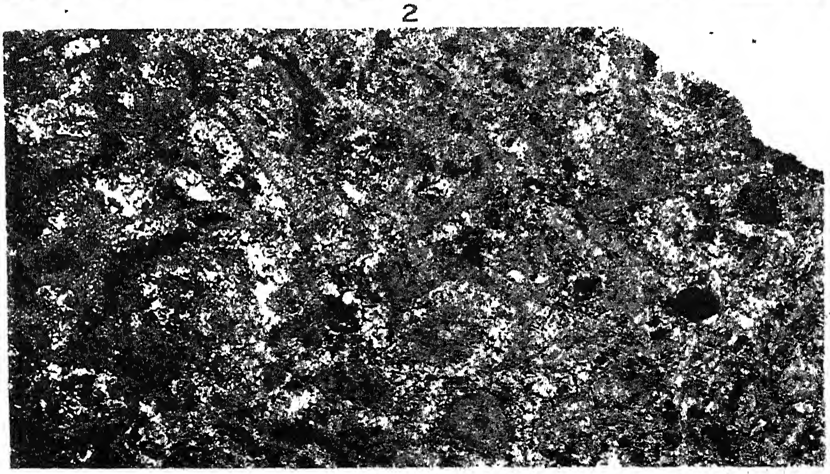

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Some Characteristics of Queensland Rain Forests and Rain-Forest Trees.

By W. D. Francis, Assistant Government Botanist.

Very few field observations of our rain-forest or so-called "scrub" trees appear to have been made and recorded by botanists, although the open or hardwood forest trees, especially the Eucalypts, have received a considerable amount of attention. Perhaps the difficulties of determining the rain-forest species in the field may account for part of the botanists' neglect of them, as the recognition of the various species in their wild state presents several obstacles, such as the inaccessibility of the leaves, flowers, and fruit, the apparent similarity of so many of the trees, and the very large number of species crowded into a limited area.

In the latter part of this paper the writer has endeavoured to facilitate the recognition of some of the rain-forest trees by placing on record some of their peculiarities. It is not claimed that these peculiarities are exhibited in all cases, but experience has shown that a large number of them is serviceable in the field in the specific, generic, or ordinal determinations in which they are stated to be applicable. Most of the observations were made by the writer during a residence of several years in the rain forest at Kin Kin, North Coast line, or whilst on short official visits to rain forests in various parts of the State.

It is well known that the Eastern Australian rain-forest flora, in contrast with the true or old Australian type of vegetation as exemplified by the Eucalyptus forests, is allied to the Papuan and Malayan floras, and is often referred to as chiefly constituting the Austro-Malayan type. Although allied to Papuan and Malayan ones, the great majority of the Australian rain-forest species is endemic.

THE RELATION OF RAIN FORESTS TO RAINFALL.

The dependence of our luxuriant rain forests upon heavy rainfall is unquestionable. The heavy or luxuriant

rain-forest areas of the State appear to have an average annual rainfall approximating or exceeding 60 inches. The areas in which this condition of rainfall prevails generally, if not always, contain relatively large areas of rain forest of the luxuriant type. A meteorological map showing the distribution of rainfall in Queensland indicates roughly the following areas with rainfalls approximating or exceeding 60 inches annually:—

(1) The extreme south-eastern portion of the State, including the MacPherson Range and Tambourine Mountain;

(2) The North Coast line district, between Landsborough and Cooran;

(3) The small area round Yeppoon;

(4) The area between Mackay and Proserpine;

(5) The fairly large area to the north, south, and west of Cairns; and

(6) The northern part of Cape York Peninsula.

All of these areas, with the possible exception of Cape York Peninsula, whose flora is not very well known, contain tracts of heavy rain forest. Following are the average annual rainfall registrations, in inches, of meteorological stations situated in or near the rain forests of the areas enumerated:—

(1) Tweed Heads 70, Tambourine Mountain 64;

(2) Landsborough 67, Montville 70, Nambour 60, Cooran 56, Kin Kin 57;

(3) Yeppoon 65;

(4) Eungella 72 for 1913, Mackay 69; and

(5) Cairns 90, Atherton 53, Harvey's Creek 165.

It is evident that the luxuriant rain forests are indicative of a heavy rainfall.

On the other hand, certain types of vegetation—for example, brigalow (*Acacia harpophylla*) "scrub"—indicate a relatively low rainfall. Extensive areas of brigalow forest occur between Dalby and Roma on the Western, between Warwick and Goondiwindi on the South-Western line (C. T. White), and between Westwood and Emerald on the Central line. These three areas have an average annual rainfall of

from 20 to 30 inches. The prevalence of brigalow in coastal areas, as at Marmor, south of Rockhampton, with an average rainfall of 34 inches at Raglan (the nearest meteorological station), and at Rosewood, with 32 inches, appears to signify coastal localities with low rainfalls.

Rain forests of a type less luxuriant than those of the fertile areas of MacPherson Range and the North Coast line occur in many parts of the State, especially in the coastal area. Following are some of the locations of these less heavy rain forests, with the annual rainfall of the locality in parentheses:—Myer's Ferry, near Southport (55), Rosewood (32), Goodna (37), Imbil (45), Theebine (40), Marmor (Raglan, nearest station, 34). This type, which is not so aptly described by the term "rain forest," occurs in areas of great or less extent from the Tweed River in the south to Rockhampton, and probably, from what the writer has heard, as far as Cooktown in the north.

THE RELATION OF RAIN FORESTS TO SOIL.

Both the luxuriant and the less heavy types of rain forest abound on soils derived from various kinds of rock. Following is an enumeration of some of the heavy rain-forest areas, showing the kinds of rock from which the soils are derived:—The MacPherson Range areas, such as Roberts' Plateau, Tambourine Mountain (basalts and andesites)[1]; Blackall Range (basalts) (H. I. Jensen); Kin Kin (phyllites and slates)[2]; the area between Beenham Range and Kin Kin (granodiorite)[3]; and the Eungella Range, westward of Netherdale, Mackay district (granodiorite).[4]

SOME EFFECTS OF SOIL, RAINFALL, AND CLIMATE ON RAIN FORESTS.

The character of the luxuriant rain forests of areas such as Tambourine Mountain, Kin Kin, and Eungella Range shows that in those localities the conditions of soil and rainfall approach the optimum. The heavy rain forests of the MacPherson Range, such as those of Roberts' Plateau,

[1] H. C. Richards, Proc. Roy. Soc. Q., Vol. xxvii, plate x (1916).

[2] L. C. Ball, Q'land Govt. Mining Journ., p. 58, Vol. xix., Feb. 1918.

[3] L. C. Ball, loc. cit.

[4] L. C. Ball, Q'land Geo. Survey Pubn. No. 224, p. 27 (1910).

are situated at an altitude of 3,000-4,000 feet, and the climate is therefore temperate. They only differ in general character from those at lower levels further north, where the climate is subtropical, in containing less undergrowth. The less luxuriant types of rain forest often grow in poor soils, especially where the rainfall is high. This fact is exemplified at places such as Myer's Ferry, south of Southport, where a rain forest of the lighter kind flourishes in the sandy soil adjacent to the ocean beach. The soil in this and similar localities is composed of grains of silica in very high proportions, and plant food must be present in low percentages. In cases of this kind it appears obvious that a heavy rainfall (55 inches in this instance) is a very decisive factor in determining the character of the forest. On the other hand, in localities where the soil is fertile a rain forest of the lighter type is generally the result of a light rainfall. These conditions are seen in the light rain forests in the neighbourhood of Theebine (Kilkivan Junction), where the average annual rainfall is 40 inches and where the fertility of the soil is exhibited by the good crops grown in the felled areas.

SIZE OF RAIN-FOREST TREES.

Queensland rain-forest trees do not often exceed 160 feet in height and 6 feet in barrel diameter when measured above the basal flanges or plank buttresses. The fig trees (*Ficus* spp.), Queensland kauri pines (*Agathis* spp.), scrub box (*Tristania conferta*), and some species of Eucalypts such as the messmate (*Eucalyptus Cloeziana*) and the flooded gum (*E. saligna*), when growing in the luxuriant rain forests sometimes exceed 6 feet in barrel diameter. The Eucalypts which sometimes grow in the rain forests or on their margins often exceed the true rain-forest trees in height, but they do not grow beyond 200 ft. in height, so far as the writer is aware. The common form of rain-forest tree has a long barrel bearing a shorter canopy of branches and foliage. In some cases the barrels attain 80 or 90 ft. in height before they branch. In the light rain forests the size of the trees is sometimes reduced so that the general height is brought down to about 40 or 50 feet, and the barrel diameter of the larger trees to 12 or 18 inches.

BUTTRESSED BARRELS.

Many rain-forest trees are deeply flanged or buttressed (plank-buttressed) at the base of the barrel, a peculiarity which appears to be exhibited by certain species of trees in dense rain forests in tropical and subtropical parts of the world. J. H. Maiden[5] has recorded the buttressed character of several common Australian rain-forest trees. A. F. W. Schimper[6] remarks that the plank-buttress is a peculiarity of trees in a tropical climate with abundant rainfall, that the amount of rainfall necessary for its appearance is not yet ascertained, and that the physiological causes of the phenomenon and its significance to the life of the tree are still obscure. As plank-buttresses are common in all of the luxuriant rain forests mentioned previously in this paper, even in those at an altitude of 3,500 feet in latitude 28·2 degrees south, on the MacPherson Range, it can be definitely stated that in Queensland the phenomenon is not confined to tropical forests, but occurs in relatively temperate climates, and that it appears when the annual rainfall approximates or exceeds 60 inches.

A large number of species of Queensland rain-forest trees have plank-buttresses. Following are the most conspicuous trees which exhibit this peculiarity:—Fig trees (*Ficus* spp.), the carribin (*Sloanea Woollsii*), blueberry ash (*Elæocarpus obovatus*), quandong (*Elæocarpus grandis*), mountain beech (*Elæocarpus Kirtonii*), *Dysoxylon* spp., booyong (*Tarrietia argyrodendron*) and its varieties, black jack (*Tarrietia actinophylla*), water gum (*Eugenia Francisii*), *Eugenia Luehmanni*, *Eugenia* spp., red cedar (*Cedrela toona*, var. *australis*), marara (*Weinmannia lachnocarpa*), pink marara (*Geissois Benthami*), and the giant ironwood (*Syncarpia subargentea*). The buttresses of some species often assume characteristic shapes. For example, the carribin (*Sloanea Woollsii*), which is one of the most conspicuously buttressed trees, frequently has flanges whose edges curve outwards.

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[5] J. H. Maiden, "Australian Vegetation," Federal Handbook on Australia, issued in connection with visit of British Assn., 1914, p. 172.

[6] A. F. W. Schimper, "Plant Geography," trans. W. R. Fisher, revised and edited, Groom and Balfour, p. 305 (1903).

CHARACTERISTICS OF SOME RAIN-FOREST TREES.

Trees with Channeled or Fluted Barrels.—Some species are characterised by channeled or fluted barrels which are angular or sub-angular in cross-section. Unlike the buttressed trees, the channeled or fluted character is not always confined to the basal portion of the barrel, but often extends upwards towards the lowermost limbs. Examples are the churnwood or soap box (*Villaresia Moorei*), lignum-vitæ (*Vitex lignum-vitæ*), black apple or black plum (*Sideroxylon australe*), koda (*Ehretia acuminata*), she pine or brown pine (*Podocarpus elata*), giant stinging tree (*Laportea gigas*), scrub turpentine (*Rhodamnia trinervia*), and white myrtle (*Rhodamnia argentea*). Occasionally the churnwood, lignum-vitæ, and koda resemble each other in general appearance. The churnwood is one of the largest trees of the rain forests, and attains a barrel diameter of nearly 5 feet. It has a pale or whitish cork-like fissured bark. Its timber is pale or nearly white, and is remarkable for its broad medullary rays, which in tangential section measure 2-4 mm. or more in height. The lignum-vitæ has a bright yellow bark when cut. The rays of the timber are fine and inconspicuous, measuring from ·2-·7 mm. in height in tangential section. The koda (which is an Indian name for the species) is generally not so tall as the churnwood and lignum-vitæ, and it is frequently almost leafless in the spring. The rays of its timber appear to the unaided eye as minute specks which measure ·5-1·5 mm. in tangential section.

Trees with Conspicuously Fissured Barks.—The following rain-forest trees have prominently fissured barks comparable to that of ironbark:—Scrub ironbark (*Bridelia exaltata*), white cedar (*Melia Azedarach*), and red ash (*Alphitonia excelsa*).

Trees with Scaly Barks.—The scaly-barked trees are numerous. Some of the common species are bolly gum (*Litsea reticulata*), crow's ash (*Flindersia australis*), yellow-wood (*Flindersia Oxleyana*), crow's apple (Owenia *venosa*), red cedar (*Cedrela toona*, var. *australis*), white beech (*Gmelina Leichhardtii*), rosewood (*Dysoxylon Fraseranum*), scentless rosewood (*Synoum glandulosum*), deep yellow-wood (*Rhodosphæra rhodanthema*), and southern penda (*Xanthostemon oppositifolius*).

Trees with Very Smooth, Thin Barks.—The ironwood (*Myrtus Hillii*) and the giant ironwood (*Syncarpia subargentea*) have very smooth, thin barks. The bark of an ironwood 10 inches in barrel diameter measured $\frac{1}{16}$-inch thick; and that of a giant ironwood 3 feet in diameter $\frac{1}{8}$-inch thick. In both trees the surface of the bark is often bright-green or bright-brown. The ironwood rarely exceeds 10 inches in barrel diameter. The marara (*Weinmannia lachnocarpa*) has a thin but not very smooth bark, which measures $\frac{3}{16}$-inch on a tree with a barrel diameter of 2 feet 3 inches, and which is generally deep-red when cut.

Trees with Yellow Inner Barks.—The following trees have yellow inner barks:—Black bean or Moreton Bay chestnut (*Castanospermum australe*), lignum-vitæ (*Vitex lignum-vitæ*), blueberry ash (*Elæocarpus obovatus*), mountain beech (*Elæocarpus Kirtonii*), quandong or blue fig (*Elæocarpus grandis*), *Elæocarpus foveolatus*, *Elæocarpus ruminatus*, and *Elæocarpus sericopetalus*. The species of *Elæocarpus* generally have a yellow surface on the sapwood, which is seen when the bark is removed. This peculiarity is often a well-marked one, and proved serviceable to the writer recently in locating species of *Elæocarpus* in the Eungella Range. The inner surface of the bark in these trees is generally similarly tinted. It was noticed in the case of the blueberry ash that after some hours' exposure the yellow colouration turned to a bluish tint.

Trees with Ochre-Coloured Inner Barks.—At least two species of trees of the natural order *Celastrineæ*—namely, the ivorywood (*Siphonodon australe*) and the orange bark (*Celastrus dispermus*)—have very distinctive inner barks. When the outermost layer of bark is removed an inner layer of an ochre-yellow or brown colour is exposed in the ivorywood and an orange-coloured layer in the orange bark. This peculiarity of these two trees was pointed out to me by bushmen and others. Somewhat similarly coloured inner barks may be found in other species of this natural order.

Trees with a Wrinkled Surface on the Sapwood.—A large number of trees of the natural order *Sapindaceæ* and a few of the natural order *Laurineæ* have a peculiar wrinkled surface on the sapwood which is seen when the bark is removed. The wrinkles are disposed longitudinally and suggest the appearance of corduroy cloth, or in coarser

examples, such as that provided by a species of *Cryptocarya*, they simulate the corrugations of a washing-board. This wrinkled surface has so far been observed in the following species of *Sapindaceæ*:—Native tamarind (*Diploglottis Cunninghamii*), *Cupania xylocarpa*, *Ratonia pyriformis*, *R. tenax*, corduroy (*R. stipitata*, wrinkles prominent), small tamarind (*Nephelium Lautererianum*, wrinkles prominent), *Nephelium semiglaucum*, *Heterodendron oleæfolium*, and *H. diversifolium*. The Lauraceous trees which exhibit this peculiarity are few in number. One of them is an undetermined species of *Cryptocarya* (referred to above) from Eungella Range, which is the only locality in which the wrinkled surface has so far been observed in *Laurineæ*.

Occurrence of Black Wood (Ebony) in Queensland Ebenaceæ.—The species of the natural order *Ebenaceæ*, of which there is a considerable number in our rain forests, very frequently contain patches, streaks, or specks of black wood similar in appearance to the ebony of commerce (species of *Diospyros* and *Maba*). These black patches, streaks, or specks have been observed in the following species of the order in Queensland:—*Maba humilis*, *M. geminata*, *M. fasciculosa*, *M. reticulata*, black myrtle (*M. sericocarpa*), *Diospyros pentamera*, and *D. hebecarpa*. In *Maba humilis*, which is known as native ebony, the black wood is developed in fairly large quantities. Solereder[7] states that the black colour of ebony is due to black or brown contents present in the wood vessels and in the lumina of the wood prosenchyma: that Belohoubek has shown that part of the black contents is soluble in caustic potash, and is due to humic acid whilst the part insoluble in alkalies consists essentially of carbon; and that Molisch had shown earlier that the black contents arise by a process of humification from a gum present in the cell lumen.

Trees with Very Soft Woods.—The giant stinging tree (*Laportea gigas*), glossy-leaved stinging tree (*Laportea photiniphylla*), flame tree (*Brachychiton acerifolium*), scrub bottle (*Brachychiton discolor*) and the Queensland bottle tree (*Brachychiton rupestre*), which is sometimes found in the light rain forests, have very soft, porous woods. The woods of *Panax elegans* and *P. Murrayi* are also soft, but not to the same degree as those of the stinging trees.

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[7] Solereder, "Systematic Anatomy of the Dicotyledons," trans. Boodle and Fritsch, revised D. H. Scott, Vol. I, p. 518 (1908).

Trees with Woods Depositing Brightly-coloured Ashes.—A limited number of rain-forest trees, when burnt, deposit coloured ashes which are noticeable in newly burnt felled "scrub." Among the most conspicuous examples are the bonewood, pink-heart or native orange (*Medicosma Cunninghamii*), which deposits a bright blue ash, and the ironwood (*Myrtus Hillii*), which deposits a bright yellow ash. The bonewood, which rarely exceeds a barrel diameter of 9 inches, owes its common name to the brittleness of the wood which is brought under the notice of axemen by the circumstance that the first blow with the blade of the axe often detaches a large flake of the bark and wood. The name pink-heart originates from the bright pink central heartwood which often traverses the barrel.

Trees with Coloured Woods.—A very large number of trees have coloured woods. but only a few of the more distinctive ones can be mentioned here. The deep yellow-wood (*Rhodosphaera rhodanthema*) has a bright yellow heartwood. The wood of yellow sassafras (*Doryphora sassafras*) is also bright yellow. The black bean (*Castanospermum australe*), lignum-vitæ (*Vitex lignum-vitæ*), and hauer (*Dissiliaria baloghioides*) have dark-coloured heartwoods which generally fade to a lighter colour after a few weeks' exposure. The tulip wood (*Harpullia pendula*) has dark streaks in its heartwood. Trees with red woods are numerous; among the more common are red cedar (*Cedrela toona* var. *australis*), rosewood (*Dysoxylon Fraseranum*), scentless rosewood (*Synoum glandulosum*), maiden's blush (*Sloanea australis*), red ash (*Alphitonia excelsa*), onion-wood (*Dysoxylon* sp.), red bean (*Dysoxylon* sp.) and crow's apple (*Owenia venosa*).

The Large Medullary Rays of Proteaceæ.—It is well known to wood technologists and others that large and conspicuous medullary rays are very often charcteristic of the woods of many species of the natural order *Proteaceæ*, such as the silky oaks and beefwoods (*Grevillea* spp., *Macadamia* spp., *Orites excelsa, Cardwellia sublimis, Stenocarpus* spp.). The ends of these large rays are visible as small more or less elliptical spots on the surface of the sapwood when the bark is removed. The "soft tissue" or wood parenchyma of Proteaceous timbers is very frequently arranged in short lines transverse to the medullary rays.

Trees Exuding Latex.—A number of trees exude a milky juice or latex when the bark, sapwood, or succulent parts is cut or ruptured. This group includes the majority of the Queensland species of the natural order *Sapotaceæ*, comprising the genera *Sideroxylon, Chrysophyllum, Lucuma, Hormogyne* and *Mimusops*; many species of the natural order *Urticaceæ* such as the species of fig trees (*Ficus*) and the axe-handle-wood (*Pseudomorus Brunoniana*); several species of the natural order *Euphorbiaceæ* such as the scrub poison tree (*Excæcaria Dallachyana*) and the majority of the species of the natural order *Apocynaceæ* such as *Alstonia* spp. including the native quinine tree (*Alstonia constricta*) and the milky pine (*A. scholaris*), *Cerbera odollam* and *Ochrosia* spp. Among the species of figs, *Ficus stenocarpa* is exceptional, as its juice is not milky. The flow of latex from species of *Ficus* and *Excæcaria* is generally copious.

Trees Whose Sap or Woody Parts Change Colour on Exposure.—The scrub bloodwood (*Baloghia lucida*), a tree rarely exceeding 1 foot in barrel diameter, has a bark more or less stained by a reddish brown sap which is frequently transformed into scattered hardened spots or nodules giving the bark a rather rough appearance. When the bark is freshly cut the sap appears colourless and turns bright red after a few seconds' exposure to the air. The native olive (*Olea paniculata*) attains about 1 foot 8 inches in barrel diameter in South Queensland rain forests. The barrel is sometimes flanged at the base and the bark on large trees slightly fissured or wrinkled with small warts arranged in longitudinal lines or rows in the wrinkles or shallow fissures. The bark and sapwood when freshly cut are white or pale, but turn pink after being exposed to the air for ten or fifteen minutes.

Trees Whose Freshly Cut Bark and Sapwood have a Characteristic Odour.—The mango bark (*Bursera australasica*) possesses an odour of mangoes in its freshly cut bark and sapwood. The sassafrases (*Cinnamomum Oliveri, Doryphora sassafras,* and *Daphnandra aromatica*) have a strong smell of sassafras. Native cascarilla (*Croton insularis*) has an odour like that of official cascarilla bark (*Croton Eleuteria*). Red cedar (*Cedrela toona* var. *australis*), rosewood (*Dysoxylon Fraseranum*) and incense

wood (*Amoora nitidula*) have an aroma like that of the cedar oil used for oil immersion lenses, the aroma being present in the timbers, too. Some species of *Dysoxylon* have a disagreeable odour like that of onions and are, accordingly, sometimes called "onionwood" by bushmen. The turnip-wood (*Akania Hillii*) has a strong odour of turnips. *Panax elegans*, sometimes known as celery-wood, has a faint smell of celery. Black bean (*Castanospermum australe*) has a pumpkin or cucumber-like smell. Species of the natural order *Laurineæ* generally possess more or less fragrant barks. The aroma of the bark and wood of red cedar is often noticeable in the crushed green leaves, and is sometimes a useful means of identifying them.

Trees with Deciduous Leaves.—The majority of Queensland rain-forest trees is evergreen. The following species, however, are deciduous:—red cedar, white cedar, (*Melia Azedarach*), and *Ficus Cunninghamii*. The koda (*Ehretia acuminata*), *Ficus gracilipes*, flame tree (*Brachychiton acerifolium*), scrub bottle tree (*Brachychiton discolor*), Burdekin plum (*Pleiogynium Solandri*), and the Mackay cedar (*Albizzia toona*) are partly, if not truly, deciduous, and are often seen with very young leaves in the spring or early summer months—September, October, or November.

Trees with Leaves which Turn a Brilliant Red Colour in Age.—The leaves of the quandong (*Elæocarpus grandis*) and the mountain beech (*Elæocarpus Kirtonii*) turn a brilliant red colour in age. They are often conspicuous on the trees and on the ground beneath. Another species, the so-called native "bleeding heart" (*Homalanthus populifolius*), which rarely attains the size of a timber tree and is more commonly seen as a shrub, has leaves which turn a deep red colour when old.

ACKNOWLEDGMENTS.

The writer is indebted to the Commonwealth Meteorologist's (Mr. Hunt's) work "Rainfall Observations in Queensland" for the rainfall data contained in the paper.

THE

ROYAL SOCIETY OF QUEENSLAND.

ABSTRACT OF PROCEEDINGS.

REPORT OF COUNCIL FOR 1921.

To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting its Report for 1921.

During the year ten papers were read before the Society and published. In addition, the following lectures, to which the public were invited, were delivered:—"Glacial Man," by Prof. S. B. J. Skertchly, a past President of the Society; "The Aborigines of Central Australia," Captain S. A. White; "Plant Distribution in the United States," Prof. D. H. Campbell; "The Relation of the Oil Fields of the World to the Continental Shelves of the Archæan Continents," Dr. H. I. Jensen; "Australian Marsupials," Prof. W. K. Gregory. The attendance in each case was very gratifying.

As in previous years the Queensland Government voted £50 to the Society for the publication of scientific papers, and acknowledgment of this practical assistance is hereby made. We also wish to acknowledge subsidies by the Trustees of the Walter and Eliza Hall Fund towards defraying the cost of the following papers by Prof. T. H. Johnston and O. W. Tiegs, M.Sc. (Walter and Eliza Hall Fellow in Economic Biology):—"New and Little-known Sarcophagid Flies from South-Eastern Queensland" and "On the Biology and Economic Significance of the Chalcid Parasites of Australian Sheep Maggot-flies." The cost of publishing the paper by Prof. T. H. Johnston and Miss M. J. Bancroft, B.Sc. (late Walter and Eliza Hall Fellow in Economic Biology), entitled "The Freshwater Fish Epidemics in Queensland Rivers," was also borne by the Trustees of the Walter and Eliza Hall Fund.

During the year there have been eleven meetings of the Council, the attendances being as follows:—C. T. White

(President) 8, E. W. Bick 9, W. H. Bryan 7, B. Dunstan 3, W. D. Francis 10, E. H. Gurney 4, T. H. Johnston 8, H. A. Longman 8, H. J. Priestley 7, H. C. Richards 10, J. Shirley 10, F. B. Smith 3.

The roll of members consists of ten corresponding and ninety-two ordinary members and three associates. Three resignations were accepted.

With deep regret we record the death of Dr. R. L. Jack, one of our life members, and formerly Government Geologist of Queensland. The late Dr. Jack distinguished himself in geological research in Queensland, in which he was a pioneer, and in Great Britain before the inception of his notable work in this State.

Our thanks are tendered to the University of Queensland for affording accommodation for meetings and for housing the library.

In September, 1921, the Council was unfortunately obliged to discontinue the publication of papers on account of lack of funds, and for that reason several papers handed into the Society could not be published at that time. At a later date the financial position improved owing to the receipt of delayed subscriptions.

A special effort has been made to place the finances of the Society on a satisfactory footing, with the result that after meeting all outstanding liabilities there is a balance of £35 5s. 7d. in hand.

C. T. WHITE, *President.*

W. D. FRANCIS, *Hon. Secretary.*

THE ROYAL SOCIETY OF QUEENSLAND.

BALANCE-SHEET FOR YEAR ENDED 31st DECEMBER, 1921.

Cr. Dr.

Expenditure.	£	s.	d.
Printing (Pole and Co.)	111	4	0
Printing (Government Printer)	164	0	6
Hon. Secretary	11	0	0
Hon. Treasurer	2	12	6
Insurance	0	18	0
Cost of Public Meeting (National Park)	2	0	0
Expenses of Lecturer	3	0	0
Dishonoured Cheque	2	11	0
Bank Charge	0	10	0
Cheque Book	0	5	0
Exchange	0	4	2
Bank Balance	35	5	7
	£333	10	9

Receipts.	£	s.	d.
By Bank Balance	101	10	8
Subscriptions	103	0	9
Payments for Authors' Copies and Illustrations	71	16	9
Government Subsidy	50	0	0
Refund of Unexpended Grant	2	0	0
Sale of Proceedings	1	0	0
Discount (Pole and Co.)	2	15	1
Council Levy	1	7	6
	£333	10	9

Examined and found correct.
H. J. PRIESTLEY,
Hon. Auditor.

JOHN SHIRLEY, Hon. Treasurer.
1st March, 1922.

Abstract of Proceedings, 11th April, 1922.

The Annual General Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on 11th April, 1922. His Excellency Sir Matthew Nathan, G.C.M.G., the Patron, was in the chair.

It was moved by Prof. T. H. Johnston, seconded by Prof. H. C. Richards, and carried unanimously, that the action of the Council in postponing the Annual Meeting from March be confirmed.

His Excellency referred in highly appreciative terms to the work of the late Dr. Shirley, and proposed that a letter of condolence be forwarded to Mrs. Shirley. The motion was seconded by Mr. H. A. Longman, supported by Prof. Skertchly, and carried unanimously.

The minutes of the last Annual General Meeting were read and confirmed.

The Annual Report and Financial Statement were adopted on the motion of Mr. J. B. Henderson, seconded by Mr. E. H. Gurney.

Dr. A. J. Sawyer was elected as an Ordinary Member of the Society.

The following officers were elected for 1922:—

President: Professor H. J. Priestley, M.A.

Vice-Presidents: C. T. White, F.L.S. (*ex officio*); Dr. E. O. Marks, B.A., B.E.

Hon. Secretary: W. D. Francis.

Hon. Editor: H. A. Longman, F.L.S.

Hon. Librarian: W. H. Bryan, M.Sc.

Members of Council: E. H. Gurney, Dr. H. I. Jensen, Professor T. H. Johnston, Professor H. C. Richards, and E. H. F. Swain.

It was proposed by Prof. Johnston, seconded by Mr. Longman, and carried, that Mr. E. W. Bick be appointed Acting Honorary Treasurer.

Mr. H. A. Longman, F.L.S., exhibited a live specimen of the "Ribbon-tailed Gecko" (*Diplodactylus tænicauda* De Vis), which had been donated to the Queensland Museum by Mr. E. S. Barton, of Mount Darry, *viâ* Toowoomba. The ribbon-like streak of tawny colour on the tail is a remarkable feature of this lizard.

Prof. T. H. Johnston, M.A., D.Sc., exhibited specimens of *Opuntia monocantha* which were destroyed or in process of being destroyed by the so-called "Wild Cochineal Insect" (*Coccus indicus*), the progeny of material forwarded by the Prickly-pear Travelling Commission (consisting of Mr. H. Tryon and himself). The original material was collected in India and Ceylon, whence it was sent to Queensland early in 1913. This particular species of insect is responsible for the annihilation of *Opuntia monocantha* from Queensland.

Messrs. S. R. L. Shepherd, L. F. Hitchcock, and G. H. Hardy were proposed for ordinary membership.

The retiring President, Mr. C. T. White, F.L.S., delivered his address, entitled "A Contribution to our Knowledge of the Flora of Papua (British New Guinea)."

A vote of thanks to the lecturer was proposed by Prof. Johnston, seconded by Mr. Tryon, supported by Prof. Skertchly, and carried unanimously.

A Paper by the late Dr. Shirley, entitled "Marine Mollusca from New Guinea," was tabled and taken as read.

Professor Richards, seconded by Mr. Longman, moved a vote of thanks to His Excellency for presiding.

Abstract of Proceedings, 31st May, 1922.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Wednesday, 31st May, 1922.

The President, Prof. H. J. Priestley, M.A., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. J. S. Just was unanimously elected as an ordinary member.

Drs. J. V. Duhig and A. H. Marks were proposed for ordinary membership.

Mr. W. H. Bryan, M.Sc., exhibited a fine specimen of a large ammonite from the Walsh River, showing cavities filled with calcite and quartz crystals, which had been presented to the Queensland Museum by Mr. J. Clark. Mr. Bryan identified the fossil as *Crioceras plectroides*, Eth.

Mr. C. T. White, F.L.S., exhibited (1) specimens of *Bambusa Moreheadiana*, Bail., a common climber in the scrubs (rain forests) of the Russell River area (bamboos are tropical plants which reach their greatest development in Southern and Eastern Asia. The group is represented in Australia by only two species); (2) fruits of *Garcinia Xanthochymus*, Hook. f., a native of India, cultivated in North Queensland; the specimens were gathered by Mr. W. J. Ross from a tree growing at Edge Hill, near Cairns; (3) resin exuded by *Calophyllum Inophyllum*, Linn., collected on Daru Island by Mr. J. Cowling.

Mr. H. A. Longman, F.L.S., exhibited a mounted specimen of an unusually large bandicoot recently killed in Brisbane and donated to the Queensland Museum. He suggested that the large bandicoots occasionally found in South Queensland were the result of the ample diet provided by the introduction of sweet potatoes. In view of variations associated with growth, especially in the mandible, he thought that the supposed specific distinctions between the Northern bandicoots, *Isoodon macrurus* and *torosus* and the Southern *I. obesulus* should be maintained only as subspecies, especially as some of the South Queensland specimens had the characteristics of the Northern form. Mr. Longman also exhibited a fossil fragment of a reptilian mandible, articular portion, found in the Rewan Police Paddock, Rolleston district, given to him by Dr. Jensen. Although too incomplete to be further determined, the fragment presented characteristics unknown in any fossil or existing Australian reptile.

Dr. H. I. Jensen, in communicating his paper entitled "Some Notes on the Geology of Northern Australia," delivered a lecture on the geology of that part of the continent. He explained how the swing of the trend lines of the folded Silurian and Devonian rocks implied the geographical unity of North-West Queensland, the Northern Territory, and the West Australian massif as far back as the Precambrian; the Palæozoic sediments were moulded upon the old continent and increased its area in an easterly direction. The undisturbed nature of the Permo-Carboniferous in North Queensland shows that the whole of the North of this State became part of the Gondwana continental mass in late Palæozoic times, the Permo-Carboniferous sediments being left by what Suess calls a transgression.

But the major portion of Eastern Queensland was a geosynclinal not only in Palæozoic times but also through most of the Mesozoic era. Folding movements in South-Eastern Queensland have lasted even to the Tertiary. Prof. Richards, Mr. W. H. Bryan, and Dr. E. O. Marks took part in the subsequent discussion.

ABSTRACT OF PROCEEDINGS, 26TH JUNE, 1922.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 26th June, 1922.

The President, Prof. H. J. Priestley, M.A., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. J. C. McMinn was proposed for ordinary membership.

Drs. J. V. Duhig and A. H. Marks were unanimously elected as ordinary members.

Mr. C. T. White, F.L.S., pointed out the desirability of establishing an arboretum at Victoria Park, and moved that the Secretary be instructed to write to the City Council and suggest that a project with this end in view be inaugurated. The motion was seconded by Mr. E. W. Bick, supported by Prof. H. C. Richards, D.Sc., and carried unanimously.

On behalf of Mr. H. A. Longman, Dr. E. O. Marks, B.A., B.E., exhibited a piece of sandstone from Adavale showing obscure markings like impressions of the foot of a kangaroo. Dr. Marks also exhibited a specimen of slag from Mount Morgan.

Mr. W. H. Bryan, M.Sc., exhibited an excellent specimen of foraminiferal limestone purchased by Miss C. Moxon in Cairns. The polished faces showed well-preserved sections of *Fusulina japonica*, which is the most characteristic carboniferous foraminifer of Eastern Asia.

In communicating his paper entitled, "The Geology and Petrology of the Enoggera Granite and Allied Intrusives, Part II., Petrology," Mr. Bryan gave a general

account of the series of granitic rocks lying on the western outskirts of Brisbane. After discussing the place of these rocks in the geological history of Southern Queensland, and showing that they could be closely correlated with the granites of the Stanthorpe and New England Districts, he described some of the more prominent of the many varied rock types to be met with in the area. Prof. Richards, Dr. E. O. Marks, Messrs. Bennett, Gurney, and White took part in the subsequent discussion.

Abstract of Proceedings, 31st July, 1922.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 31st July, 1922.

His Excellency the Governor, Sir Matthew Nathan, P.C., G.C.M.G., attended by Captain Hammond, A.D.C., was present and presided over a crowded audience.

The minutes of the previous meeting were taken as read.

Mr. J. C. McMinn was unanimously elected to ordinary membership.

Professor H. C. Richards, D.Sc., then gave an address on "Kosciusko: The Roof of Australia," in which the parts played by Strzelecki, W. B. Clarke, Von Lendenfeld, Helms and David in elucidating the geological and glacial history were pointed out; also the more recent work of E. C. Andrews and Griffith Taylor, and its significance, was indicated. The geological history of the Kosciusko mass, especially in its relationship to the surrounding country, was considered; also the glaciation to which the area has been subjected. By means of lantern slides and blackboard diagrams the topography and glacial features were illustrated.

On the motion of Dr. H. I. Jensen and Mr. A. J. Thynne, supported by His Excellency the Governor, a vote of thanks was extended to the lecturer.

ABSTRACT OF PROCEEDINGS, 31ST AUGUST, 1922.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Thursday, 31st August, 1922.

The President, Professor H. J. Priestley, M.A., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. P. A. L. Dunne, who was a member of the party which established the cyclone-warning station on Willis Island, exhibited a large number of specimens, including shells and corals collected during his visit, and gave a general account of conditions on the island. Professor Richards commented on Mr. Dunne's exhibit.

Professor H. C. Richards, D.Sc., read a paper entitled "Anorthoclase Basalt from Mapleton, Blackall Range, South-eastern Queensland." The rock described is the first basic alkaline lava containing anorthoclase described from Queensland. It occurs near the head of the Mapleton Falls, 2 miles south-west of Mapleton. The flow has abundant lozenge-shaped phenocrysts of anorthoclase, and rests on top of an olivine basalt. It is Upper Cainozoic in age, and is the concluding effusion of the most recent volcanic activity. Chemically it differs from the normal basalts forming the Blackall Range in having lower alumina, more iron oxides, less magnesia, considerably less lime, more soda, and twice as much potash. It has chemical characters similar to those of an oligoclase basalt from Spicer's Peak, Main Range, and of a basalt from Mount Lindsay, Macpherson Range. The Spicer's Peak basalt is the concluding effusion of the Upper Cainozoic activity, and the Mount Lindsay basalt of the Lower Cainozoic activity. The similarity of these concluding flows and their departure from the normal seem to be more than a coincidence. Dr. E. O. Marks and Mr. J. H. Reid discussed the paper.

Mr. J. H. Reid read a paper entitled "A Note on the Walloon Jurassic Flora." The author concludes:—(1) That *Thinnfeldia*, the predominant genus of the Ipswich beds, appears to be practically, if not absolutely, absent from the Walloon in the Moreton and Roma Districts; (2) that the large-leaved *Tæniopteridæ*, as well as *T. Tenison-Woodsi* and *T. Dunstani*, similarly do not ascend into the

Walloon as far as we know, this genus being only represented (though in great abundance) so far by *T. spatulata;* (3) that *Cladophlebis australis* is predominant in the Walloon. Professor Richards, Dr. Marks, and Mr. Bryan discussed the paper.

A paper by Mrs. B. B. Grey, F.L.S., entitled "Notes on Species of Sagitta Collected during a Voyage from England to Australia," was tabled and taken as read.

ABSTRACT OF PROCEEDINGS, 26TH SEPTEMBER, 1922.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Tuesday, 26th September, 1922.

The President, Prof. H. J. Priestley, M.A., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

The following papers were tabled and taken as read:—

By Prof. T. H. Johnston, M.A., D.Sc., and O. W. Tiegs, M.Sc.: "New and Known Sarcophagid Flies." In this paper two new species are described, and a new genus proposed for the reception of a previously-named species. Additional locality records are given for many other species belonging to this family of blowflies.

By Prof. T. N. Johnston and G. H. Hardy: "A Synonymic List of Some Described Australian Calliphorine Flies." The paper records the results of an attempt to elucidate the abundant synonymy which exists in regard to the commonest Australian Calliphorine blowflies.

Mr. H. A. Longman, F.L.S., exhibited (1) the skin and skull of an albino wallaby, *Macropus dorsalis,* donated to the Queensland Museum by Mr. R. D. Wearne, Biggenden; (2) a very large cuttle bone collected by himself on Stradbroke Island, the dimensions of which were: Maximum length (not quite complete), 487 mm.; maximum breadth (incomplete), 158 mm. The specimen was compared with Pilsbry's *Sepia hercules,* but probably represents a distinct species.

Mr. C. T. White, F.L.S., delivered a lecture entitled "The Eucalypts of the Brisbane District." He stated that the Eucalypts were distinctly Australian trees. Although a few North Australian species spread to New Guinea, Timor, and the Philippine Islands, there was no country other than Australia with endemic species of the genus. The genus Eucalyptus probably contains about 350 species. Of these, between seventy and eighty occur in Queensland, and twenty-one species are to be found growing within about a 10-mile radius of the City of Brisbane. The species occurring about Brisbane can be classified for practical purposes into five groups: (1) Gums proper or smooth-barked trees, six species, *Eucalyptus hæmastoma* var. *micrantha* (Scribbly Gum), *E. tereticornis* (Blue Gum), *E. propinqua* (Grey Gum), *E. Seeana* (Narrow-leaved Blue Gum), *E. maculata* (Spotted Gum), and *E. saligna* (Flooded Gum); (2) the stringybarks and mahoganies, seven species, *E. acmenioides* (Yellow Stringybark), *E. acmenioides* var. *carnea* (Yellow Stringybark), *E. umbra*, *E. eugenioides* (White Stringybark), *E. resinifera* (Red Stringybark), *E. Baileyana*, *E. Planchoniana* and *E. Microcorys* (Tallow-wood); (3) the ironbarks, four species, *E. paniculata* (Grey Ironbark), *E. crebra* (Narrow-leaved Ironbark), *E. siderophloia* (Broad-leaved Ironbark), and *E. melanophloia* (Silver-leaved Ironbark); (4) the boxes, one species, *E. hemiphloia* (Gum-topped Box); and (5) the Bloodwoods, three species, *E. corymbosa* (Red Bloodwood), *E. trachyphloia* (White Bloodwood) and *E. tesselaris* (Moreton Bay Ash). A vote of thanks was accorded the lecturer on the motion of Prof. Richards, seconded by Dr. E. O. Marks, and supported by Prof. Johnston and Messrs. Longman, Swanwick, and Bennett.

Abstract of Proceedings, 30th October, 1922.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 30th October, 1922.

The President, Prof. H. J. Priestley, M.A., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. H. A. Longman, F.L.S., exhibited a single large fossil vertebra recently found near Dalby by Mr. Thos. Jack, who donated it to the Queensland Museum. He identified it as one of the caudals of *Megalania prisca*, an ally of the monitor lizards or "goannas" of to-day, but which was about 18 feet in length.

Mr. W. H. Bryan, M.Sc., exhibited a fossil specimen of a species of the class Equisetales which was found in the Brisbane tuff at Morningside by Miss Moxon.

Prof. H. C. Richards, D.Sc., read a paper entitled, "An Unusual Rhyolite from the Blackall Range." The rhyolite, which is at least 1,000 feet thick, forms the Bon Accord Falls in Skene's Creek and the Narrows in the Obi Obi Creek. Chemically the rock is very remarkable, and a comparison with other analyses shows that it is one of the most acid lavas yet recorded. Its high silica content of over 85 per cent., together with its low alumina content of about 5½ per cent., show its remarkable chemical characters. It is believed that heated waters containing silica, carbonic acid gas, &c., have been responsible for the alteration of the original rhyolite, and that these waters are of magmatic origin, and acted during the last stages of cooling down of the lava. The term deuteric has been given to these reactions by Sederholm, and they are believed to be much more common than hitherto understood.

Messrs. W. H. Bryan, E. H. Gurney, F. Bennett, and Dr. E. O. Marks took part in the subsequent discussion.

ABSTRACT OF PROCEEDINGS, 24TH NOVEMBER, 1922.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in conjunction with that of the Royal Geographical Society of Australasia (Queensland) in the Geology Lecture Theatre of the University at 8 p.m. on Friday, 24th November, 1922.

His Excellency Sir Matthew Nathan, P.C., G.C.M.G., presided.

The minutes of the last meeting were taken as read.

Sir Matthew Nathan and Professor H. J. Priestley referred appreciatively to the scientific work of Professor

T. H. Johnston and to his active interest in the Royal Society and the Royal Geographical Society, and deeply regretted his departure from the State.

Drs. R. W. Cilento and S. Fancourt McDonald were nominated for ordinary membership.

Professor F. Wood-Jones, D.Sc., M.B., B.S., delivered a lecture on "Corals," giving a lucid exposition of his researches at the Cocos-Keeling atoll.

A vote of thanks to the lecturer was proposed by Prof. Richards, seconded by Prof. Johnston, supported by His Excellency, and carried by acclamation. Reference was made to the important work to be undertaken by the Barrier Reef Research Committee, and the hope was expressed that Prof. Wood-Jones would be able to take an active part in some phase of its activities.

A paper by Mr. W. D. Francis, entitled "Some Characteristics of Queensland Rain Forests and Rain-Forest Trees," was tabled and taken as read.

Publications have been received from the following Institutions, Societies, etc. and are hereby gratefully acknowledged.

AFRICA.

Durban Museum, Durban.

AMERICA.

BRAZIL—

Instituto Oswaldo Cruz, Rio Janeiro.

CANADA—

Department of Mines, Ottawa.
Royal Canadian Institute, Toronto.
Royal Astronomical Society of Canada, Toronto.
Royal Society of Canada, Ottawa.

UNITED STATES—

American Academy of Arts and Sciences, Boston.
American Geographical Society, New York.
Academy of Natural Science, Philadelphia.
American Philosophical Society, Philadelphia.
Californian Academy of Science, San Francisco.
Indiana Academy of Science.
Rochester Academy of Science.
National Academy of Science and Smithsonian Institute, Washington.
Library of Congress.
American Museum of Natural History, New York City.
New York Zoological Society, New York.
Department of Agriculture.
Arnold Arboretum.
Department of Commerce, New York.
Missouri Botanic Gardens, St. Louis, Missouri.
University of California, Berkeley.
University of Colorado.
Cornell University.
John Hopkins University.
University of Illinois, Urbana.
Ohio State University.
University of Kansas, Lawrence.
University of Minnesota, Minneopolis.
Oberlin College.
National Research Council.
Buffalo Society of Natural Science.
Portland Society of Natural History.
Lloyd Library.
Bernice Pauahi Bishop, Museum, Honolulu, Hawaiian Islands.

MEXICO—

Instituto Geologico de Mexico, Mexico.
Sociedad Cientifica, Mexico.

ASIA.

INDIA—

Colombo Museum, Colombo, Ceylon.
Agricultural Institute, Pusa, Bengal.
Geological Survey of India.
Superintendent, Government Printing.
Survey of India, Dehra Dun.

JAVA—

Department van Landbrouw, Batavia.
Koninclklyke Naturkundige, Batavia.

PHILIPPINE ISLANDS—

Bureau of Science, Manila.

AUSTRALIA AND NEW ZEALAND.

QUEENSLAND—

Field Naturalists' Club, Brisbane.
Geological Survey of Queensland, Brisbane.
Queensland Museum, Brisbane.
Government Statistician, Brisbane.

NEW SOUTH WALES—

Australasian Association for the Advancement of Science, Sydney.
Department of Agriculture, New South Wales.
Botanic Gardens, Sydney.
Geological Survey of New South Wales, Sydney.
Public Library, Sydney.
Linnean Society of New South Wales, Sydney.
Australian Museum, Sydney.
Royal Society of New South Wales, Sydney.
Naturalists' Society of New South Wales, Sydney.
University of Sydney.

VICTORIA—

Bureau of Census and Statistics, Melbourne.
Royal Society of Victoria, Melbourne.
Field Naturalists' Club, Melbourne.
Department of Agriculture, Melbourne.
Department of Mines, Melbourne.
Australasian Institute of Mining and Metallurgy, Melbourne.
National Museum, Melbourne.
Institute of Science and Industry, Melbourne.
Scientific Australian.

TASMANIA—

Royal Society of Tasmania, Hobart.
Field Naturalists' Club, Hobart, Tasmania.
Geological Survey of Tasmania.

South Australia—

Royal Society of South Australia, Adelaide.
Royal Geographical Society of South Australia, Adelaide
National Museum of South Australia, Adelaide.
Geological Survey of South Australia, Adelaide.

West Australia—

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Geological Survey of West Australia, Perth.

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OF THE

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OF

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FOR 1923.

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Proceedings of the Royal Society of Queensland for 1923.

Presidential Address.

By H. J. Priestley, M.A.

(Delivered before the Royal Society of Queensland, 26th March, 1923.)

Before proceeding with the main topic of my address, I should like to refer to three matters mentioned in the Annual Report.

You will have noticed how large a proportion of our annual expenditure is devoted to printing. Like all other scientific societies we are badly hit by the increased cost of publication, and I would urge on members the need for continued efforts to maintain and increase our resources.

A gratifying feature of last year's work is the co-operation between our Society and the Royal Geographical Society. It is to be hoped that we may see a gradual drawing together for mutual support of all kindred societies in Brisbane. In such a way we might diminish the evils of isolation, serious everywhere, but especially serious in a city far from the main centres of intellectual activity.

During the past year we have lost by death two ordinary members and one corresponding member of the Society—Dr. Alfred Sutton, Mr. James Johnston, and Professor J. A. Pollock.

At the outbreak of war in 1914 Dr. Sutton was principal medical officer of the Queensland Military District. He left Australia with the first expeditionary force as Lieutenant-Colonel in command of the Third Field Ambulance, and was present at the landing on Gallipoli. For his services throughout the war he was appointed a Companion of the Orders of the Bath and St. Michael and St. George, and a Knight of Grace of the Order of St. John of Jerusalem.

Mr. James Johnston entered the service of the Department of Public Instruction in 1881 as a pupil teacher at Warner. He served as assistant teacher at Warner and

Fortitude Valley, and head teacher at Aramac, Emu Vale, Ashgrove, Kangaroo Point, Bundaberg, and Townsville. He became a district inspector in January, 1914, and continued his work in that capacity till his death last September.

Professor POLLOCK was appointed to the Chair of Physics in the University of Sydney in 1899. He did not confine his energies to his own department or his own University, but was always willing to bear his share of the general scientific work of Australia. He was a Fellow of the Royal Society of London, and an ex-President of the Royal Society of New South Wales and of Section A of the Australasian Association. Many of us who worked with him at the meetings of the Association will always remember with gratitude the encouragement which he gave to those younger and less experienced than himself. During the war Professor Pollock did valuable work at the Front in connection with practical applications of the theory of sound.

ON THE DEVELOPMENT OF SCIENTIFIC THOUGHT.

During a visit to England some three years ago it was my privilege to dine with one of the most distinguished living mathematicians. In the course of conversation we discussed the published proceedings of a celebrated mathematical society, and my host said, "What I object to in that publication is that only once in six months does it contain a paper that a man can understand." This remark emphasizes a great difficulty and a great danger in modern scientific work. Recent advances have been so varied and so rapid that no man can keep in touch with all developments, even in one branch of science alone. We are compelled to specialize and our sphere of work is confined to a comparatively small region of one of the main subdivisions of science. It is sometimes advisable, however, to turn from the cultivation of our own small fields and look out over the landscape as a whole. Accordingly I propose to-night to direct your attention to some points in the past history of scientific thought and to a danger which appears to underlie some of the modern work.

It is frequently asserted that Greek Science was based on metaphysical calculations unchecked by experiment or

observation. Like most other generalizations this embodies an element of truth, but, if interpreted too literally, it is apt to be misleading. Burnet, in his history of Early Greek Philosophy, accounts for the origin of the idea in the fact that the records we possess are mainly statements of results. These by themselves, without any indication of the methods by which they were obtained, certainly convey the impression that they were dogmatically asserted opinions. We know, however, that the Greeks had at their disposal a large body of observational facts obtained by the Chaldæan astronomers and the Egyptian surveyors. Furthermore, there are indications that opinions that at first sight appear to be fallacious metaphysical assumptions are, in actual fact, erroneous deductions from accurate observation. For example, Xenophanes asserts that "all things are earth and water." We might be tempted to take this as evidence of the Greek tendency to formulate a system of Natural Philosophy based on arbitrary assumption, were it not for the fact that we have other records in which it is stated that "Xenophanes said that a mixture of the earth with the sea is taking place and that it is gradually being dissolved by the moisture. He says that he has the following proof of this:—Shells are found in midland districts and on hills; and he says that in the quarries at Syracuse has been found the imprint of a fish and of seaweed, at Paros the form of an anchovy in the depth of the stone, and at Malta flat impressions of all marine animals."

From this it appears that his assertion was not based on mere assumption but was a faulty deduction from observation.

As another example, consider a view of eclipses that was current in the early days of Greek Astronomy: The sun is a bowl full of burning material which normally has its concave side towards us, but which is occasionally reversed. This is not a wholly unreasonable interpretation of observed phenomena in the infancy of scientific thought; the prominences visible during a solar eclipse might quite well be taken for flames showing over the edge of the inverted bowl.

It is certain, then, that in some cases Greek scientific views arose as interpretations of experimental evidence;

interpretations, it is true, which appear fanciful and extravagant in the light of modern knowledge but which were not unreasonable at the time they were put forward. It may quite well be argued that Greek scientific method was not, as is commonly believed, pure metaphysical speculation, but rather the modern method in its early stages of development. The formulation of hypotheses to explain observations, one of the main features of modern work, was certainly practised by the Greeks and probably originated with them; for there is nothing to suggest that Babylonian or Egyptian science was anything more than an accumulation of observed facts. It should be borne in mind, however, that the Greek showed little sign of realizing the necessity of step-by-step progress. Throughout the whole course of Greek Natural Science we find a tendency to base a big generalization on a few observations; there is very little of that gradual building up of scientific theory that is characteristic of modern work, but there are constant attempts to pass from preliminary observation to final law of nature by great flights of the imagination. Science in its early days was afflicted by that common infirmity of youth, the desire to hurry on to the goal by short cuts; it was not until age and experience added caution and hard work to the brilliance and enthusiasm of youth that any lasting progress was made. It seems probable, however, that the main cause of the ultimate sterility of Greek Science was not so much rashness in the formulation of hypotheses as failure to check hypotheses by means of further observation or experiment. It is not strictly true to say that the test experiment was absolutely unknown, but it is certain that it was rare; in its absence hypotheses were apt to become extravagant, and, moreover, their authors were forced back on to metaphysical arguments in defence of them. Thus metaphysics gradually expelled experience from scientific work till, in the Middle Ages, Science was practically smothered under a mass of meaningless verbiage which had little relationship to reality.

Yet while realizing this the modern scientist should be cautious in his criticism of his predecessors in ancient or mediæval times. It is easy nowadays to laugh at the old idea that the circle is the only perfect curve and therefore the paths of the planets must be described in

terms of circular motion; an idea from which even Kepler found it hard to break away and which hindered the development of Astronomy; but it is not a great time since Biology and Geology were handicapped by a universal belief in the literal truth of the early chapters of Genesis, and at the present day Einstein is assailed with arguments based on the assumption of the objective reality of the Æther.

The reaction against the barren metaphysical science of the Middle Ages set in towards the end of the sixteenth century and gradually gathered strength. The state of affairs in the early eighteenth century is well shewn up in the editor's preface to the second edition of Newton's Principia, published in 1713. In this preface Cotes, Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge, summarizes the methods of the old and new schools of thought, and refers in addition to a third school occupying an intermediate position. That the new views had not found universal acceptance is evident from the fact that he considers it advisable to devote considerable space to a refutation of the Cartesian Vortex Hypothesis. In view of the light thrown on the scientific thought of Newton's day by this preface, I ask your attention to a somewhat free translation of some extracts.

"Students of Physics can be divided into three classes. For there are some who attribute specific and occult qualities to the several species of things from whence they derive, I know not by what process of reasoning, the behaviour of individual bodies. Herein is found the whole doctrine of the schoolmen, derived from Aristotle and the Peripatetics; they assert that each individual effect arises from the special natures of bodies; the origin of those natures they do not tell and hence they teach us nothing. Since all is in the names of things, not in the things themselves, we can allow that they have found a certain philosophical language, but they have given us no Philosophy.

"Others, again, have hoped to gain credit for better discretion by rejecting this useless accumulation of words. They maintain that there is a universal homogeneous matter and that all variety of types which is observable in bodies arises from the simplest and easily understood relationships.

of their component particles. Indeed a certain advance is made here, passing from simpler to more complex phenomena, if to these particles they attribute no relationships other than those shewn in Nature. But when they take on themselves to postulate arbitrary unknown shapes and sizes and doubtful positions and motions, and further to invent some occult fluid, freely permeating bodies, endowed with perfect mobility and disturbed by occult motions; then are they given over to dreams, to the neglect of the real nature of things which, truly, is sought in vain by fallacious guesses seeing that it can with difficulty be studied by means of the most careful observations. Those who base their investigations on hypothesis, even if they then proceed most accurately according to the Laws of Mechanics, may be said to concoct fables, neat perhaps and beautiful but fables nevertheless.

"There remains the third school, which concerns itself with Experimental Philosophy. Its members attempt to derive the causes of all things from the simplest principles possible but they admit as a principle nothing that is not given by observed phenomena. They do not invent hypotheses and introduce them into Physics except as propositions into whose truth they must inquire. Their method falls into two divisions, one Analytic the other Synthetic. The forces of Nature and the simpler laws of forces are deduced by analysis of certain selected phenomena, and from them is found by synthesis the nature of the remainder."

The method outlined in the last paragraph shews the main characteristics of modern scientific method; the selection of the more outstanding results of observation for detached analysis, the formulation of a provisional hypothesis as a possible explanation the validity of which is to be tested further, the application of results obtained from the simpler problems in the building up of a general theory covering more complex cases, are all in keeping with our present-day views. It shews a marked advance on the earlier method of attempting to pass in one bound from observation to general theory.

The need to proceed carefully to the hypothesis after preliminary analysis and selection of data had been shown by the failure of the old ways; the possibility of so doing

had come with the improvement in means of observation and in the development of mathematical knowledge. An example of the importance of this progress is found in Kepler's work. Kepler's laws of planetary motion arose from his study of the observations of Mars recorded by Tycho Brahe, in whose observatory he was an assistant. At the beginning of the work, under the sway of the old idea of the perfect circular motion, he attempted to describe the motion of the planet by means of epicyclics and very nearly succeeded. In his own account of his investigations we read:—

"Since the divine goodness has given to us Tycho Brahe, a most careful observer, from whose observations the error of 8′ is shown in this calculation, it is right that we should with gratitude recognize and make use of this gift of God. For if I could have treated 8′ of longitude as negligible I should have already corrected sufficiently the hypothesis discovered in Chapter XVI; but as they could not be neglected, these 8′ alone have led the way towards the complete reformation of Astronomy."

Thus Kepler was warned off his epicyclic hypothesis by a discrepancy of eight minutes between calculated and observed results, an amount that could not have been detected by any Greek observer. Furthermore, his final explanation was in terms of the ellipse, a curve discovered by the Greek geometers, certainly, but unknown before metaphysics had obtained its hold on Greek Science.

The fact that he arrived at a law that could not have been obtained by a Greek astronomer does not necessarily imply the superiority of his method, but may have arisen from the superiority of the means at his disposal.

The detailed analysis of observations involved in the new scientific method required much description of phenomena and thereby caused an all-important change in the viewpoint of the scientific world. The question "Why" had dominated the older thought, but emphasis now was placed on the question "How." It is unlikely that Newton and his contemporaries had adopted our modern view that the business of Science is to give an ordered description of phenomena and has no concern with first causes; but it is certain that they realized that

adequate ordered description must provide the starting point of any further investigation. Some passages in Newton's Principia have a distinctly modern ring; in particular the notes on the definitions show that many terms are intended to embody brief descriptions and carry no physical significance. For example, consider this passage:—

"I use the terms 'attraction' and 'impulse' in the sense of 'source of acceleration' and 'source of motion.' I use 'attraction,' 'impulse,' 'tendency towards a centre,' indifferently and as mutually interchangeable; these are to be understood not as physical but as mathematical concepts. Hence, let the reader beware of thinking that when I speak of 'the attraction of a centre' or 'central forces' I mean to imply any particular mode of action, or physical cause, or to attribute real physical powers to the centres (which are mathematical points)."

This quotation provides the key to the whole scheme of the Principia. The first two books are concerned with a mathematical description of a certain type of motion, and the third book discusses various problems in connection with the motion of the planets, moon and comets, tidal phenomena, and the precession of the equinoxes. These are all explained in terms of gravitational forces corresponding to the "attractions" of the first two books. Thus the whole work is devoted to the investigation of how our system moves. To extend the inquiry to the cause of this motion, it would first be necessary to pass from gravity as a convenient name to denote a source of acceleration towards a material particle, to gravity as an agency causing that acceleration by definitely explained means.

Newton saw that this transition could not be made by means of further study of his phenomena, and, true to the new ideals of science, he refused to make it in any other way. The final Scholium to the Principia contains this passage:—

"I have not been able to deduce the reason of these properties of Gravity from the phenomena and I frame no Hypothesis. For whatever is not deducible from phenomena must be called hypothesis; and hypotheses whether metaphysical, or physical, or of occult qualities, or mechanical, have no place in Experimental Philosophy.

In this Philosophy propositions are to be deduced from phenomena and generalized by induction.

It is sufficient for us that Gravity exists and, acting according to the laws we have put forward, is adequate to explain the motions of the heavenly bodies and the sea."

I have given these extracts from the Principia to illustrate the change of opinion as to the function of Science. The change of method is brought out more clearly by a consideration of the history of the origin of Newton's great work. Tycho Brahe had accumulated by observation a mass of data on the positions of the planets; Kepler, starting from the hypothesis that the path of Mars is an epicyclic, failed to account for observed facts and formulated the elliptic hypothesis. This covered the facts as far as Mars was concerned, so he extended it by a tentative assumption that all the planetary orbits are ellipses with the sun at one focus. This generalization was found to fit the facts and was enunciated in 1609 as Kepler's First Law. The second law appeared in the same year and the third ten years later. In 1638 Galileo published his Dialogues on Two New Sciences, which contained the results of his work on falling bodies. The immediate result was the concentration of the scientific world on the problem of Gravitation.

Halley, Wren, Huygens, and Hooke all attacked the subject. Assuming tentatively that the planets were kept in their elliptic orbits by a force of the same nature as that causing bodies to fall to the earth, and, simplifying their problem by assuming circular in place of elliptic orbits, they deduced from Kepler's Third Law that the attraction of the sun or earth on an external body must vary inversely as the square of the distance between the attracted and attracting masses. In passing we might notice here two characteristics of the new method; the attempt to find a single explanation of apparently different but possibly related phenomena; and the simplification of the problem by ignoring temporarily certain of the data, in this particular case the ellipticity of the orbit. The first is in accordance with the accepted "Rule," which was afterwards enunciated in the Principia, "No more natural causes are to be admitted than are sufficient to account for the phenomena"; the second follows the practice adopted by

Kepler in concentrating on one planet, Mars, before attempting to describe the motion of all. The law of attraction derived from the simplified problem could be nothing more than a tentative suggestion. This was realized by its authors, who attempted to establish it more firmly by mathematical proof that under such a law and such a law only could Kepler's Laws be true. In this attempt they evidently failed, for in August 1684 Halley visited Cambridge to consult Newton on the subject.

The particular question to which he wanted an answer was, "What is the path of a planet under the inverse square law?" Newton had already attacked the problem and promised to send him a proof of the fact, discovered in 1679, that the path is an ellipse. On receiving this document in November, Halley was so impressed with its importance that he made a special journey to Cambridge to persuade Newton to attack the whole problem of gravitation and to publish the results. The outcome was the publication of the Principia in 1687.

I have given you this brief summary of the history of the Principia because it provides an excellent illustration of scientific method. We might notice again the main features: the careful accumulation of data by Tycho Brahe followed by the analysis and concise summary of the facts by Kepler; the realization of the possible connection between the fall of bodies to the earth and the planetary motions; the framing of a tentative hypothesis suggested by a simplified problem, and finally a verification of the hypothesis by working out its implications and comparing them with the results of observation.

Before leaving this page of the history of Science, I would call your attention to the part played by Halley. Edmund Halley is generally known from his prediction of the return of the comet which bears his name; his great claim to the gratitude of the scientific world lies in his labours in connection with the Principia. Newton was notoriously reluctant to publish his work, and it is to Halley that the Principia owes its existence, as is shown in Newton's own preface—

"In producing this Edmund Halley, that man of great intellect and learning, laboured most earnestly. Not only did he correct the proofs and get the type engraved,

but he was the originator of the whole work. For when I had shown him that I had discovered the nature of the motion of the celestial bodies he never ceased to ask me to communicate it to the Royal Society; till at last he succeeded by his importunity and kindly encouragement in making me think of publication."

We know from other sources that Halley bore a large part of the cost of publication and dropped his own researches for a year or two in order to keep Newton up to the mark and push the great work through the press. The world owes much to the genius of Newton, but it owes no less to the perseverance, generosity, and self-sacrifice of Halley.

Two facts stand out in the above outline of the development of scientific thought: the sterility of mediaeval science under a weight of metaphysical speculation, and the fertility restored by a return to experience which in less than a century produced the Principia. In view of these facts it was natural that subsequent developments should be characterized by a distrust of metaphysics. In the light of recent research, however, it appears that a wrong attitude to metaphysical questions may again lead to the stagnation of scientific work. We noticed, earlier in the evening, that one difference between ancient and modern science is the difference of aim; the old search after first causes has been replaced by attempts to formulate ordered descriptions. We no longer accept Newton's rule and reason that "no more causes are to be admitted than are sufficient to explain the phenomena, because, as the philosophers say, Nature does nothing in vain and it is vain to use many means when few will suffice. Nature is simple and does not run riot with superfluous causes." Rather do we accept the dictum of the French philosopher who said that Nature pays no heed to the difficulties of analysis, while at the same time we attempt to summarize our description of Nature in as few and as general statements as possible. Since our aim is description we are not concerned with the metaphysical problem of reality. The Newtonian scheme of Space and Time forms an adequate framework for the Newtonian Mechanics in terms of which has been built up a system of Natural Philosophy that has served us for two hundred years; the question of the

objective reality of Space and Time, as explained in the well-known and oft-quoted Scholium, does not affect the adequacy of this system as a means of description.

Again, the Æther provides a convenient means of describing electromagnetic phenomena, but the description is equally satisfactory whether we regard the Æther as a mental concept or, alternatively, as an entity having real objective existence.

It is certainly true that Natural Science as such has no concern with Metaphysics, but we must take care to give the correct meaning to the assertion. Metaphysical questions may be safely ignored as unsolved but irrelevant; it is dangerous to avoid them by a tacit and unconscious assumption of a particular solution. A besetting sin of the scientific worker is a tendency to assume a realist solution of metaphysical problems; and the tendency is all the more dangerous in that it is unconscious.

Consider, for example, the idea of space. By a process of abstraction from observations of material bodies the idea is developed and refined until we have the full concept of a three-dimensional continuum, subject to the laws of Euclidean Geometry, in which material bodies exist. By a metaphysical assumption this is endowed with objective reality and immediately certain consequences follow; among others, displacements are combined by the parallelogram law and length becomes an intrinsic absolute property of material bodies. These are spoken of as facts of experience; whereas they are actually the outcome of experience combined with certain metaphysical assumptions. Our direct experience indicates that length is a relation between object and observer which changes with change of relative position, but we introduce our assumptions about space and, by correcting for change of position, attribute absolute length to the object.

Now nothing is gained by this tendency towards realism; absolute length as a fact of experience is of no more value in scientific work than absolute length as a convenient interpretation of experience. On the other hand much flexibility is lost; if we accept absolute length as fact we are limited in our interpretation of further experience, if we look upon it as interpretation we can modify that interpretation as further experience demands.

The tendency towards realism, which is all too common in the scientific world, arises mainly from the concentration of individual workers on their own fields at the expense of due consideration of general scientific development. The scientist should take the advice so often tendered to politicians and social reformers—Read history! A thoughtful study of the history of the growth of science reveals the arbitrary nature of our current views, which have been adopted for convenience, not of necessity. Since all the sciences are influenced by Physics, it is sufficient to notice the way in which physical science develops by mutual reaction between mathematical theory and physical observation. Observation suggests postulates for mathematical theory, and deductions from these postulates are tested by further observations. In order to carry out the tests it is necessary both to attach physical significance to the concepts of the mathematical theory, as Newton did when he identified a physical force of gravity with his mathematically defined central forces, and also to decide on canons of interpretation of the observations. The arbitrary element in the latter step is apt to be overlooked: in fact, great man as Helmholtz was, he failed entirely to recognize it when he undertook his experiment to determine whether space was subject to the laws of Euclidean Geometry. It was left to Poincare to point out that Helmholtz's result was susceptible of two interpretations: space is Euclidean and a beam of light is straight, or space is non-Euclidean and a beam of light is curved. Further, it could not be upheld that the first interpretation must be taken on the grounds that Physics had already shown that light travelled in straight lines, for this fact was not a necessary conclusion from experience but merely a possible interpretation of experience. To return to the main question, when physical significance has been given to the mathematical theory, and when canons of interpretation of observations have been adopted, comparison can be made between theoretical and experimental results. Discrepancies between the two are reconciled by modifying the mathematical theory, the physical interpretation of the theory, or the interpretation of observations. By the constant interaction of theory and experiment a consistent

scheme is built up, but at no stage is any step made of necessity; rather is it, in Poincare's words, "the product of unconscious opportunism."

The final test of the adequacy of the scheme as a description of the physical universe is consistency. When we have shown this consistency we have a theory which is sufficient to account for the phenomena; to deduce the necessity of the theory we should have to prove the fact that no other consistent scheme could be evolved. Thus Science establishes the sufficiency but not the necessity of its description of Nature. The common tendency is, however, to treat the sufficient explanation as a necessary description and then to materialize the concepts embodied in it.

We have seen that the revival of Science was accompanied by a change of view as to its functions. The search for first causes gave place to an attempt to formulate ordered descriptions. There is need now to realize that these descriptions are not accurate word pictures, but merely schematic representations, probably much simplified, of underlying realities. As an example of the hindrance to the progress of Science which arises from the tendency to assume one particular solution of the metaphysical problem of reality, consider the history of the Theory of Relativity.

In the last ten years Relativity has opened up a field of investigation which promises to be exceedingly fruitful. The experimental work from which the theory arises is over thirty years old, and the essential parts of the mathematical theory by which it is worked out have been in existence during the whole of that period. The delay of thirty years is due primarily to a failure to criticise the metaphysical assumptions underlying the Michelson-Morley experiment. The theory of that experiment rested on three assumptions—the reality of the Æther, and the absolute meaning of the terms "length" and "period of duration" as applied to objects and events; the last two being practically equivalent to the assumptions of the reality and mutual independence of space and time. When the experiment failed in its object, the determination of the velocity of the earth through the Æther, the scientific world turned its attention to explaining away the failure by modifying the properties of matter and ignored

the possibility of error in the metaphysical basis of the theory. It can be urged with some truth that this attempt resulted in valuable scientific progress. My point is that with the solution of the metaphysical problem left open there were two possible lines of advance, that actually followed at the time and that adopted thirty years later. The assumption of a particular solution closed one path; it is true that the path has been reopened, but the reopening was possible only after philosophical criticism had been introduced. The moral is obvious. The tacit assumption of the answers to underlying metaphysical questions restricts the possible paths of scientific progress; to reach its full development Science must invoke the aid of Philosophy.

A certain type of scientist would counter this statement with the assertion that he makes no metaphysical assumptions; he is concerned not with metaphysical reality but with physical reality of which the criterion is the possibility of measurement. This reply suggests Johnson's famous refutation of Berkeley's philosophy. The actual observations made in a scientific measurement are observations of coincidences; the completion of the process of measurement consists in the interpretation of these observations, and the interpretation involves metaphysics. It would be foolish and unnecessary to demand that the scientist should solve the metaphysical problems, but he should at least recognize when he assumes solutions.

This somewhat cursory survey of the history of scientific thought reveals two main periods: the first characterized by crude metaphysical speculation and comparatively barren; the second dominated by a return to experience, fruitful, but restricted in outlook by unconscious metaphysical assumptions. The pre-relativity work of Mach, Poincare, and others, and the general interest in the foundations of science that has accompanied the Theory of Relativity suggest that we are entering on a third period in which careful experiment will be combined with sound philosophical criticism.

If this be so we can anticipate a period no less fruitful than its predecessor, and characterized by a breadth of view which in the past has too often been lacking.

On a Tertiary Fossil Insect Wing from Queensland (*Homoptera Fulgoroidea*), with description of a New Genus and Species.

By R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), C.M.Z.S., F.L.S., F.E.S., Entomologist and Chief of the Biological Department, Cawthron Institute, Nelson, N.Z.

(Plate I and two Text-figures.)

(*Read before Royal Society of Queensland, 30th April, 1923*)

The beautiful fossil insect wing which forms the subject of this paper was discovered near Goodna, Q., by Mr. W. H. Bryan, M.Sc., Lecturer in Geology at the University of Queensland. Mr. Bryan, in sending me the fossil for description, wrote as follows :—" The specimen was collected by me from the Tertiary beds at Redbank Plains, near Goodna, at the same spot and from the same horizon as your *Euporismites balli*, described on pp. 44-45, Queensland Geol. Survey Publ. No. 253, and figured on Plate 3. Associated with these wings are a fairly rich fish fauna and a number of well-preserved dicotyledonous plants."

With regard to the age of the beds in which the fossil was found, there is some doubt, owing to lack of evidence of any Pleistocene glaciation and the absence of fossiliferous *marine* beds in the series ; but the presence immediately beneath these beds of vesicular trachyte, which Professor Richards regards tentatively as belonging to his Middle Division of the Tertiary Volcanics of Queensland, suggests a Miocene age for the fossiliferous beds themselves.

The fossil wing might at first sight be taken for one of the Psychopsid lacewings, owing to its great breadth, its general shape, and the density of its venation. But examination under a low power proves at once that it belongs to the family Ricaniidæ of the Fulgoroid Homoptera, and is very closely allied to the recent Australian genus *Scolypopa* Stål, of which

one species, *S. australis* (Walker), is the very common Passion-Vine Hopper of Eastern Australia, an insect very common throughout Queensland and the warmer parts of New South Wales. There is, indeed, no reason for not accepting the strong probability that, in this new fossil find, we have actually a species which was the direct ancestor of our common *Scolypopa*.

In order to facilitate comparison of the fossil and recent types, I have given in Text-fig. 1 a careful drawing of the actual fossil wing, which is practically complete except for the absence of the clavus or anal area, and in Text-fig. 2 a similar drawing of the forewing of *Scolypopa australis* (Walker). The fossil requires a new genus for its reception, and I propose to name it *Scolypopites bryani* n.g. et sp., the generic name indicating its close affinity to *Scolypopa*, and the specific name being a dedication to its discoverer, who is to be heartily congratulated on his find. A comparison of the venational scheme of the two genera will be found attached to the generic definition.

Order HEMIPTERA.

Sub-order HOMOPTERA.

Superfamily FULGOROIDEA.

Family RICANIIDÆ.

Genus SCOLYPOPITES n.g.

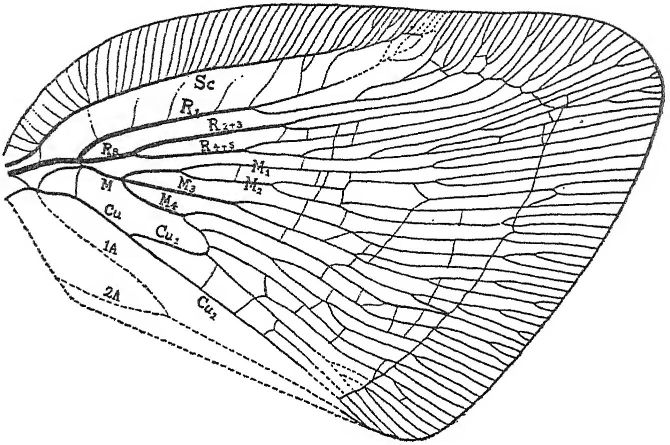
Insects of the general build and facies of *Scolypopa* Stål, with very broad, closely-veined forewings. Venational scheme very similar to that of *Scolypopa*, but more primitive in the following characters :—

(1) Sc. not so strong a vein as R, and only reaching to a little beyond the middle of the costal margin.

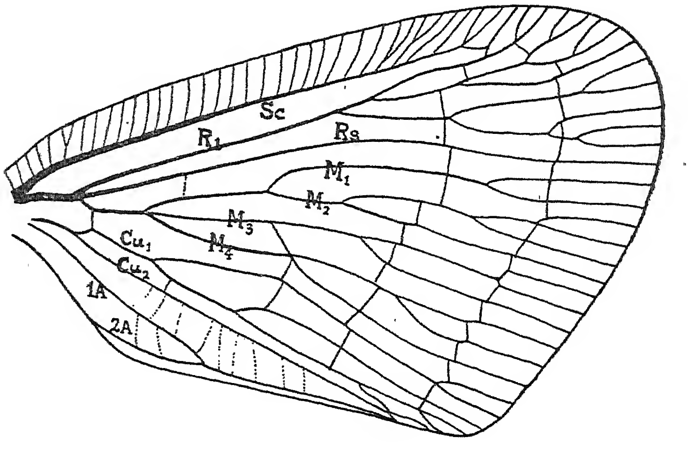
(2) M and R not completely fused at bases.

(3) Of the two gradate series of cross-veins found complete in *Scolypopa*, only the outer or marginal one is present in *Scolypopites* n.g.

As in the Psychopsid and Osmylid Lacewings, this gradate series divides the wing into a central "disc" and an outer marginal area. In *Scolypopites* n.g. there are numerous weakly formed and irregularly placed cross-veins within the disc.



TEXT-FIGURE 1 :—*Scolypopites bryani* n.g. et sp. Forewing (× 6). The missing clavus is restored by dotted lines. 1A, 2A, the two anal veins, forming the claval Y-vein ; Cu, cubitus ; Cu_1, its upper branch ; Cu_2, its lower branch, the *vena dividens* ; M, media, with its four main branches, M_1 to M_4 ; R_1, main stem of radius ; Rs, radial sector, branching into R_{2+3} and R_{4+5} ; Sc, subcosta. Tertiary (? Upper Miocene) of Goodna, Q.



TEXT-FIGURE 2 :—*Scolypopa australis* (Walker). Forewing (× 11, For comparison with Text-figure 1, which see for venational notation. (Actual size, 8 mm. long by 5 mm. wide). Recent, Eastern Australia.

Scolypopites bryani, Tillyard, n.g. et sp.

Face page 19.

In *Scolypopa* Stål, all these have been eliminated with the exception of a complete set which forms a second or *discal* gradate series, and one or two more basally situated between M and Cu.

(4) In *Scolypopites* n.g., Rs is strongly branched not far from its origin. In *Scolypopa* Stål, Rs. is either reduced to a simple vein, as in Text-fig. 2, or it does not branch until about midway along the wing.

(5) The manner of branching of M and Cu_1 in *Scolypopa* is very variable. Text-fig. 2 is taken from a specimen in which the branching of M. is trifurcate, as in the fossil. Many specimens, however, show the two veins M labelled M_3 and M_4 arising from a single stem which is itself a dichotomy with the vein marked M_{1+2} ; it is for this reason that these veins are so named. I think, therefore, that the trifurcate forking of M in *Scolypopites* n.g. may be only an individual character of this particular wing, and so I do not propose to include it in the generic definition. For the same reason I omit mention of the particular form of branching of Cu_1 and its manner of connection with M_4, since these also are highly variable in *Scolypopa*.

GENOTYPE :—SCOLYPOPITES BRYANI n. sp.

HORIZON :—Tertiary Beds (probably Upper Miocene) of Goodna, Queensland.

Scolypopites bryani n. sp.

(Plate I and Text-fig. 1.)

The fossil consists of the tegmen or forewing only, well preserved, but with the clavus or anal area entirely absent, as is very usually the case with fossil Homoptera, owing to the deepness of the impression of the *vena dividens* (Cu_2), which causes the wing membrane to split, so that the clavus usually drifts away from the rest of the wing and becomes fossilised by itself. *Total length* 15 mm. ; *greatest breadth* (measured from tornus to costa at right angles to the latter), 9·5 mm. The impression is on a dark ochreous-brown sandstone rock, rather

soft; the outlines of most of the veins are distinct, but the impression is slightly blurred here and there. Dotted portions of R_1 and Cu in Text-fig. 1 indicate restorations where the impression is not clearly visible.

The principal specific characters are as follows:—The large size, the length and breadth being almost twice that of *Scolypopa australis*, and very much larger than usual for the family. In the venation, the very strong basal arching of the costa, and its slight waviness beyond the end of Sc; the less rounded apex compared with that of *Scolypopa australis*; the greater number and closeness of the costal and marginal veinlets, and the larger number of forkings of most of the principal branches of the main veins; also the weakness of the closure of the disc from the end of Sc to the top of the marginal gradate series near the apex.

The clavus has been restored, in Text-fig. 1, much on the lines of that of *Scolypopa australis* Stål. Weak irregular cross-veins, little more than mere impressions on the membrane, are generally present in the clavus of this species, and may well have been present also in the clavus of the fossil, but it has not been thought worth while to indicate such in Text-fig. 1. For a full comparison of the two types of venation, see Text-figs. 1 and 2.

TYPE:—Unique holotype forewing, in Coll. Geol. Dept., University of Queensland.

In conclusion, I wish to thank Mr. W. C. Davies, Curator of the Cawthron Institute, for the excellent photographic enlargement of the fossil wing from which the Plate has been prepared; owing to the dark-brownish colour of the rock it proved by no means an easy task to photograph this specimen.

Cawthron Institute, Nelson, N.Z.,

Dec. 11th, 1922.

Observations regarding the Life-Cycle of Certain Australian Blowflies.

By Professor T. HARVEY JOHNSTON, M.A., D.Sc., University, Adelaide; and G. H. HARDY, Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(Read before Royal Society of Queensland, 30th April, 1923)

Experiments in breeding blowflies previously carried out in the biological laboratory of the University, Brisbane, by Johnston and Tiegs, showed variations in regard to the duration of different stages in their life-cycle, and in order to collect additional data upon this subject similar flies have now been bred in larger numbers than previously.

Decomposing meat was exposed for a period of from six to eight hours on certain selected days during the present summer (1922-23), so that flies in the neighbourhood might be attracted to the carrion and perhaps oviposit thereon. The material was then transferred to an insectarium and completely isolated from further infestation. Each day such larvæ as had left the meat to pupate and had buried themselves in the sand prepared for them were sifted out with a sieve made of mosquito-netting and then transferred to one or more vessels containing sand, wherein they were allowed to pass their prepupal period. Each day these prepupæ were again examined, and such as had become pupæ were sifted out and transferred to the laboratory to await their emergence.

A system of consecutively numbering each batch to larvæ and pupæ as they passed through their stages enabled us to keep individual records for every specimen handled. From such records the tables published in this paper have been compiled.

Before starting these experiments various observations were made to ascertain whether the handling of prepupæ or pupæ in the above manner interfered with the various periods to any appreciable extent, but we could find no evidence for considering that it did. The conditions producing alterations in such periods as the season advanced were apparently climatic changes.

In this paper the term "prepupa" is applied to cover the maggot from the time of wandering away from the meat till it has begun to form a puparium, when further movement becomes impossible. There is reason to suppose, however, that some larvæ remain in the meat for one, two, or even more days after having become fully fed, thus extending their calculated feeding period and diminishing the recorded prepupal period. A case in point may be mentioned relating to a batch of *Sarcophaga beta* J. & T., that was bred by us and given special attention. Four days after deposition all the maggots were fully grown: nothing was left of their short food supply but slime, and five of the fifteen specimens left it to pupate, the others remaining in the slime. The next day three further specimens migrated, while the balance remained for eight more days before leaving and during the whole of this period scarcely moved their position and did not increase in size. If in the table given later in this paper, four days be allowed as the feeding period and the balance of the figures above this number be added to the prepupal period, then the latter would vary from 4 to 12 days, whilst the pupal period would vary not more than one day either side of the 14 days, this being a comparatively constant period, so that given the date of deposition and the date of emergence, the dates of other periods should be readily estimated with a reasonable degree of accuracy. Although this appears to apply to the spring and summer time, it does not hold good for the winter, when *Sarcophaga* pupæ vary widely in their pupal period. We wish to emphasise the wide variation in the length of individual life-cycles, such being probably due mainly, if not entirely, to the varying time the insect takes to pass through the prepupal condition.

The climbing abilities of blowfly maggots are great, and many prepupæ will escape if special precautions be not taken. In three of the larger series we used a metal receptacle with an inwardly curved lip, and without cracks or crevices. When sifted out from this the larvæ were then placed in a glass jar with a wide open mouth and with a shoulder sufficiently wide to again form an inwardly curved obstacle against the maggots' climbing powers. Once the insect has become sufficiently far advanced in its prepupal condition (*i.e.* after not less than three days) further precautions against escape are unnecessary, provided the maggots are not subjected to damp, which may again induce them to wander, if pupation has not actually

commenced. The meat was placed in a bare shallow dish so that the larvæ had to make a special effort to leave it, thus ensuring that none did so before they were fully fed. If the meat were placed on sand some maggots would attempt to pupate in the dish, and this would necessitate disturbing the feeding larvæ in order to procure such pupæ. Very rarely did maggots pupate in the meat, and then only if it were allowed to dry out.

Table Indicating Duration of Various Stages.

The tables below indicate a complete tabulation of individual specimens bred through from their deposition to emergence. All intermediate stages which failed to complete their development have been excluded; in other words all larvæ, prepupæ, or pupæ that died before emergence occurred, or were destroyed by parasitic agencies, have been omitted from this particular record.

The first entry in the table is intended to record that one specimen, deposited by its parent on the 12th October, finished its feeding and left the meat in which it was being bred, on the 16th, so that its larval period was four days. This specimen pupated on the 18th, thus requiring a further two days to complete its pupation, *i.e.* the prepupal stage was two days and the period from deposition to pupation (total larval period) was six. By the 26th, the imago had emerged, the pupal period being eight days and the total time from deposition to emergence fourteen.

The species of *Lucilia* used was the common blue or green bottle of Brisbane, and generally regarded as *L. sericata*. Tables 1 to 4 refer to it.

TABLE 1.

LUCILIA SP.

No. of Specimens Bred.	Date of— Deposition.	Date of— Prepupation.	Date of— Pupation.	Date of— Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	No. of Days From— Deposition to Pupation = Total Larval.	No. of Days From— Deposition to Emergence = Total Period.	No. of Days From— Prepupation to Pupation = Prepupal Period.	No. of Days From— Pupation to Emergence = Pupal Period.
	Oct.	Oct.	Oct.	Oct.					
1	12	16	18	26	4	6	14	2	8
6	12	16	19	26	4	7	14	3	7
109	12	16	19	27	4	7	15	3	8
6	12	17	19	27	5	7	15	2	8
1	12	18	19	27	6	7	15	1	8
2	12	16	20	27	4	8	15	4	7
2	12	17	20	27	5	8	15	3	7
8	12	16	19	28	4	7	16	3	9
3	12	17	19	28	5	7	16	2	9
39	12	16	20	28	4	8	16	4	8
40	12	17	20	28	5	8	16	3	8
11	12	18	20	28	6	8	16	2	8
3	12	18	21	28	6	9	16	3	7
4	12	16	20	29	4	8	17	4	9
6	12	17	20	29	5	8	17	3	9
2	12	18	20	29	6	8	17	2	9
7	12	16	21	29	4	9	17	5	8
29	12	17	21	29	5	9	17	4	8
79	12	18	21	29	6	9	17	3	8
12	12	19	21	29	7	9	17	2	8
3	12	17	22	29	5	10	17	5	7
3	12	16	21	30	4	9	18	5	9
5	12	17	21	30	5	9	18	4	9
10	12	18	21	30	6	9	18	3	9
3	12	19	21	30	7	9	18	2	9
1	12	20	21	30	8	9	18	1	9
2	12	16	22	30	4	10	18	6	8
3	12	17	22	30	5	10	18	5	8
60	12	18	22	30	6	10	18	4	8
41	12	19	22	30	7	10	18	3	8
1	12	20	22	30	8	10	18	2	8
1	12	17	22	31	5	10	19	5	9
17	12	18	22	31	6	10	19	4	9
8	12	19	22	31	7	10	19	3	9
1	12	20	22	31	8	10	19	2	9
5	12	17	23	31	5	11	19	6	8
26	12	18	23	31	6	11	19	5	8
19	12	19	23	31	7	11	19	4	8
8	12	20	23	31	8	11	19	3	8

TABLE 1—*continued.*

No. of Specimens Bred	Date of— Deposition.	Date of— Prepupation.	Date of— Pupation.	Date of— Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	No. of Days From— Deposition to Pupation = Total Larval.	No. of Days From— Deposition to Emergence = Total Period.	No. of Days From— Prepupation to Pupation = Prepupal Period.	No. of Days From— Pupation to Emergence = Pupal Period.
	Oct.	Oct.	Oct.	Oct.					
1	12	21	23	31	9	11	19	2	8
1	12	18	24	31	6	12	19	6	7
1	12	20	24	31	8	12	19	4	7
1	12	21	24	31	9	12	19	3	7
				Nov.					
1	12	17	23	1	5	11	20	6	9
1	12	18	23	1	6	11	20	5	9
6	12	19	23	1	7	11	20	4	9
1	12	17	24	1	5	12	20	7	8
27	12	18	24	1	6	12	20	6	8
7	12	19	24	1	7	12	20	5	8
6	12	20	24	1	8	12	20	4	8
2	12	21	24	1	9	12	20	3	8
1	12	18	23	2	6	11	21	5	10
1	12	18	24	2	6	12	21	6	9
2	12	19	24	2	7	12	21	5	9
18	12	18	25	2	6	13	21	7	8
14	12	19	25	2	7	13	21	6	8
2	12	20	25	2	8	13	21	5	8
1	12	19	24	3	7	12	22	5	10
7	12	18	25	3	6	13	22	7	9
3	12	19	25	3	7	13	22	6	9
1	12	16	26	3	4	14	22	10	8
5	12	18	26	3	6	14	22	8	8
8	12	19	26	3	7	14	22	7	8
3	12	17	26	4	5	14	23	9	9
5	12	18	26	4	6	14	23	8	9
6	12	18	27	4	6	15	23	9	8
4	12	19	27	4	7	15	23	8	8
1	12	20	27	4	8	15	23	7	8
1	12	22	27	4	10	15	23	5	8
3	12	19	26	5	7	14	24	7	10
1	12	22	26	5	10	14	24	4	10
2	12	19	27	5	7	15	24	8	9
4	12	19	28	5	7	16	24	9	8
10	12	18	28	5	6	16	24	10	8
2	12	16	28	5	4	16	24	12	8
1	12	20	28	6	8	16	25	8	9
2	12	19	28	6	7	16	25	9	9
3	12	18	28	6	6	16	25	10	9
1	12	17	29	6	5	17	25	12	8
9	12	18	29	6	6	17	25	11	8

TABLE 1—*continued.*

No. of Specimens Bred.	Date of— Deposition.	Prepupation.	Pupation	Emergence.	No. of Days From— Deposition to Prepupation = Larva Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
	Oct.	Oct.	Oct.	Nov.					
5	12	19	29	6	7	17	25	10	8
1	12	21	29	6	9	17	25	8	8
2	12	18	29	7	6	17	26	11	9
1	12	20	29	7	8	17	26	9	9
13	12	18	30	7	6	18	26	12	8
3	12	19	30	7	7	18	26	11	8
3	12	18	30	8	6	18	27	12	9
2	12	19	30	8	7	18	27	11	9
6	12	18	31	8	6	19	27	13	8
3	12	19	31	8	7	19	27	12	8
			Nov.						
1	12	18	1	9	6	20	28	14	8
2	12	19	1	9	7	20	28	13	8
1	12	19	2	10	7	21	29	14	8
1	12	20	2	10	8	21	29	13	8
1	12	19	3	11	7	22	30	15	8
1	12	19	4	12	7	23	31	16	8
1	12	19	5	12	7	24	31	17	7
1	12	19	5	13	7	24	32	17	8

TABLE 2.

LUCILIA SP.

No. of Specimens Bred.	Deposition.	Prepupation.	Pupation	Emergence.	Larva Feeding.	Total Larval.	Total Period.	Prepupal Period.	Pupal Period.
	Nov.	Nov.	Nov.	Nov.					
42	2	7	10	17	5	8	15	3	7
1	2	8	10	17	6	8	15	2	7
2	2	9	10	17	7	8	15	1	7
45	2	7	10	18	5	8	16	3	8
2	2	8	10	18	6	8	16	2	8
3	2	9	10	18	7	8	16	1	8
147	2	7	11	18	5	9	16	4	7
7	2	8	11	18	6	9	16	3	7
5	2	9	11	18	7	9	16	2	7
2	2	7	12	18	5	10	16	5	6
4	2	7	10	19	5	8	17	3	9
69	2	7	11	19	5	9	17	4	8
27	2	8	11	19	6	9	17	3	8
2	2	9	11	19	7	9	17	2	8
110	2	7	12	19	5	10	17	5	7
39	2	8	12	19	6	10	17	4	7
24	2	9	12	19	7	10	17	3	7

TABLE 2—*continued.*

No. of Specimens Bred.	Date of— Deposition.	Date of— Prepupation.	Date of— Pupation.	Date of— Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	No. of Days From— Deposition to Pupation = Total Larval.	No. of Days From— Deposition to Emergence = Total Period.	No. of Days From— Prepupation to Pupation = Prepupal Period.	No. of Days From— Pupation to Emergence = Pupal Period.
	Nov.	Nov.	Nov.	Nov.					
61	2	7	12	20	5	10	18	5	8
48	2	8	12	20	6	10	18	4	8
29	2	9	12	20	7	10	18	3	8
4	2	10	12	20	8	10	18	2	8
2	2	11	12	20	9	10	18	1	8
51	2	7	13	20	5	11	18	6	7
56	2	8	13	20	6	11	18	5	7
12	2	9	13	20	7	11	18	4	7
2	2	10	13	20	8	11	18	3	7
1	2	11	13	20	9	11	18	2	7
9	2	7	12	21	5	10	19	5	9
30	2	7	13	21	5	11	19	6	8
59	2	8	13	21	6	11	19	5	8
18	2	9	13	21	7	11	19	4	8
2	2	11	13	21	9	11	19	2	8
22	2	7	14	22	5	12	19	7	7
88	2	8	14	22	6	12	19	6	7
12	2	9	14	22	7	12	19	5	7
1	2	10	14	22	8	12	19	4	7
3	2	11	14	22	9	12	19	3	7
4	2	7	14	22	5	12	20	7	8
12	2	8	14	22	6	12	20	6	8
2	2	9	14	22	7	12	20	5	8
1	2	11	14	22	9	12	20	3	8
4	2	7	15	22	5	13	20	8	7
105	2	8	15	22	6	13	20	7	7
5	2	9	15	22	7	13	20	6	7
4	2	11	15	22	9	13	20	4	7
3	2	8	16	22	6	14	20	8	6
1	2	12	15	23	10	13	21	3	8
63	2	8	16	23	6	14	21	8	7
3	2	9	16	23	7	14	21	7	7
3	2	11	16	23	9	14	21	5	7
1	2	13	16	23	11	14	21	3	7
2	2	8	16	24	6	14	22	8	8
2	2	13	16	24	11	14	22	3	8
1	2	14	16	24	12	14	22	2	8
17	2	8	17	24	6	15	22	9	7
5	2	8	17	25	6	15	23	9	8
1	2	8	18	25	6	16	23	10	7
1	2	8	18	27	6	16	25	10	9
1	2	8	19	27	6	17	25	11	8

No. of Specimens Bred.	Date of— Deposition.	Prepupation.	Pupation.	Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.

TABLE 2—*continued.*

Owing to a storm at night, the following specimens were flooded out and part of their records were lost :—

	Nov.	Nov.	Nov.	Nov.					
1	2	?10	20	24	?8	18	22	?10	4
2	2	?	18	25	?	16	23	?	7
2	2	?10	20	25	?8	18	23	?10	5
2	2	?	18	26	?	16	24	?	8
2	2	?10	20	26	?8	18	24	?10	6

TABLE 3.

LUCILIA SP.

7	15	20	21	28	5	6	13	1	7
16	15	20	22	28	5	7	13	2	6
305	15	20	22	29	5	7	14	2	7
29	15	21	22	29	6	7	14	1	7
41	15	20	23	29	5	8	14	3	6
6	15	21	23	29	6	8	14	2	6
9	15	20	22	30	5	7	15	2	8
1	15	21	22	30	6	7	15	1	8
228	15	20	23	30	5	8	15	3	7
43	15	21	23	30	6	8	15	2	7
51	15	22	23	30	7	8	15	1	7
6	15	20	24	30	5	9	15	4	6
9	15	21	24	30	6	9	15	3	6
				Dec.					
3	15	20	22	1	5	7	16	2	9
3	15	20	23	1	5	8	16	3	8
1	15	22	23	1	7	8	16	1	8
60	15	20	24	1	5	9	16	4	7
22	15	21	24	1	6	9	16	3	7
44	15	22	24	1	7	9	16	2	7
5	15	20	25	1	5	10	16	5	6
3	15	21	25	1	6	10	16	4	6
2	15	22	25	1	7	10	16	3	6
9	15	23	25	1	8	10	16	2	6
1	15	20	23	1	5	8	16	3	8
6	15	20	25	2	5	10	17	5	7
4	15	21	25	2	6	10	17	4	7
1	15	22	25	2	7	10	17	3	7
6	15	23	25	2	8	10	17	2	7
1	15	24	25	2	9	10	17	1	7
2	15	24	26	4	9	11	19	2	8
1	15	20	27	4	5	12	19	7	7
1	15	24	27	4	9	12	19	3	7

TABLE 4A

LUCILIA SP.

No. of Specimens Bred.	Date of— Deposition.	Date of— Prepupation.	Date of— Pupation.	Date of— Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
	Dec.	Dec.	Dec.	Jan.					
1	18	24	27	2	6	9	15	3	6
1	18	22	27	3	4	9	16	5	7
1	18	23	27	3	5	9	16	4	7
1	18	22	29	5	4	11	18	7	7
3	18	23	29	5	5	11	18	6	7
1	18	23	30	5	5	12	18	7	6
4	18	23	30	6	5	12	19	7	7
1	18	27	30	6	9	12	19	3	7
			Jan.						
1	18	23	1	8	5	14	21	9	7
1	18	23	2	9	5	15	22	10	7
1	18	23	3	10	5	16	23	11	7

TABLE 4B.

LUCILIA SP.

No. of Specimens Bred.	Date of— Deposition.	Date of— Prepupation.	Date of— Pupation.	Date of— Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
	Jan.	Jan.	Jan.	Feb.					
1	18	23	28	4	5	10	17	5	7
1	18	23	29	5	5	11	18	6	7
1	18	26	29	5	8	11	18	3	7
			Feb.						
1	18	26	1	7	8	14	20	6	6

STATISTICS FROM OBSERVATIONS IN REGARD TO BREEDING *LUCILIA*.

Table 1.—October 12th, 1922, to November 13th, 1922.

Table 2.—November 2nd, 1922, to November 27th, 1922.

Table 3.—November 15th, 1922, to December 4th, 1922.

Table 4A.—December 18th, 1922, to January 10th, 1923.

Table 4B.—January 18th, 1923, to February 7th, 1923.

No. of Days Occupied.	1.		2.		3.		4A.	4B.
	No. of Specimens.	Percentage.	No. of Specimens.	Percentage.	No. of Specimens.	Percentage.	No. of Specimens.	No. of Specimens.
	Deposition to Prepupation (Larval Feeding Period).							
4	184	22·7	..	..	..	..	..	..
5	109	13·5	600	46·5	691	74·6	2	2
6	328	40·5	537	41·6	117	12·7	12	..
7	159	19·6	117	9·1	99	10·7	1	..
8	24	3·0	7	0·5	15	1·6	..	2
9	5	0·6	16	1·2	4	0·4	..	..
10	2	0·2	1	0·1	..	..	1	..
11	..	..	3	0·2	..	..	..	..
12	..	..	1	0·1	..	..	..	..
	Deposition to Pupation (Total Larval Period).							
6	1	0·1	..	..	8	0·9	..	..
7	133	16·4	..	..	363	39·2	..	..
8	106	13·1	99	7·7	373	40·3	..	..
9	152	18·8	257	20·0	141	15·3	3	..
10	127	17·0	328	25·4	37	4·0	..	1
11	68	8·4	231	17·9	2	0·2	4	2
12	50	6·2	145	11·2	2	0·2	6	..
13	44	5·5	119	9·2	..	..	..	1
14	28	3·5	78	6·0	..	..	1	..
15	12	1·5	22	1·7	..	..	1	..
16	22	2·7	2	0·2	..	..	1	..
17	19	2·4	1	0·1	..	..	..	..
18	21	2·6	..	..	..	..	..	..
19	9	1·1	..	..	..	..	..	..
20	3	0·4	..	..	..	..	..	..
21	2	0·2	..	..	..	..	..	..
22	1	0·1	..	..	..	..	..	..
23	1	0·1	..	..	..	..	..	..
24	2	0·2	..	..	..	..	..	..

No. of Days Occupied.	1.		2.		3.		4A.	4B.
	No. of Specimens.	Percentage.	No. of Specimens.	Percentage.	No. of Specimens.	Percentage.	No. of Specimens.	No. of Specimens.
	Deposition of Emergence (Total Period).							
13	..	..	..	..	23	2·5	..	..
14	7	0·9	..	..	381	41·2	..	..
15	120	14·8	45	3·5	347	37·5	1	..
16	104	12·6	211	16·5	153	16·5	2	..
17	142	17·6	275	21·3	18	2·0	..	1
18	129	15·9	266	20·6	..	..	5	2
19	89	11·0	118	9·2	4	0·4	5	..
20	51	6·3	266	20·6	..	..	..	1
21	38	4·7	71	5·5	..	..	1	..
22	25	3·1	22	1·7	..	..	1	..
23	20	2·5	6	0·5	..	..	1	..
24	22	2·7	..	..	..	..	..	..
25	22	2·7	2	0·2	..	..	..	..
26	19	2·4	..	..	..	..	..	..
27	14	1·7	..	..	..	..	..	..
28	3	0·4	..	..	..	..	..	..
29	2	0·2	..	..	..	..	..	..
30	1	0·1	..	..	..	..	..	..
31	2	0·2	..	..	..	..	..	..
32	1	0·1	..	..	..	..	..	..
	Prepupation to Pupation (Prepupal Period).							
1	2	0·2	7	0·6	91	9·8	2	..
2	41	5·0	18	1·4	443	47·8	1	..
3	323	40·0	188	14·5	307	33·1	1	1
4	189	23·3	338	26·2	73	7·9	3	..
5	58	7·2	314	24·3	11	1·2	6	1
6	54	6·7	186	14·4	..	..	..	2
7	38	4·7	134	10·4	1	0·1	1	..
8	18	2·2	72	5·6	..	..	1	..
9	16	2·0	22	1·7	..	..	1	..
10	19	2·4	2	0·2	..	..	..	..
11	16	2·0	1	0·1	..	..	..	..
12	22	2·7	..	..	..	..	..	..
13	9	1·1		..	..	..	..	..
14	2	0·2	..	..	..	..	..	..
15	1	0·1	..	..	..	..	..	..
16	1	0·1	..	..	..	..	..	..
17	2	0·2	..	..	..	..	..	..

	1.		2.		3.		4A.	4B.
No. of Days Occupied.	No. of Specimens.	Percentage.	No. of Specimens.	Percentage.	No. of Specimens.	Percentage.	No. of Specimens.	No. of Specimens.
Pupation to Emergence (Pupal Period).								
6	..	..	5	0·4	97	10·6	2	1
7	20	2·5	831	64·3	809	87·4	14	3
8	668	82·4	432	33·5	16	1·7	..	..
9	117	14·4	14	1·1	3	0·3	..	..
10	6	0·7	..	..	1	0·1	..	..

ADDITIONAL OBSERVATION.—One hundred and forty pre-pupæ of *Lucilia* were collected on the 28th December, completed pupation between 29th December and 10th January, emerging between 4th and 18th January, the pupal period being as follows :—

3 specimens in 5 days.
27 specimens in 6 days.
106 specimens in 7 days.
4 specimens in 8 days.

It will be noticed that during the early summer (October and early November) the great majority of pupæ required eight days before emergence, while during the remainder of November about twice as many needed only seven days as required eight, and in the following months, December and January, the great majority needed seven days. The fact that some completed their pupal stage in the short period of five days is worthy of note.

TABLE 5.

No. of Specimens Bred.	Date of— Deposition.	Prepupation.	Pupation.	Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
Genus Chrysomyia.									
C. micropogon.									
	Oct.	Oct.	Oct.	Oct.					
35	12	18	19	24	6	7	12	1	5
7	12	18	20	25	6	8	13	2	5
10	12	19	20	25	7	8	13	1	5
1	12	19	21	26	7	9	14	2	5
	Jan.	Jan.	Jan.	Jan.					
1	18	26	26	30	8	8	12	..	4
C. albiceps.									
	Oct.	Oct.	Oct.	Oct.					
1	12	18	19	24	6	7	12	1	5
1	12	18	19	25	6	7	13	1	6
1	12	18	20	25	6	8	13	2	5
C. varipes.									
	Nov.	Nov.	Nov.	Nov.					
1	2	11	11	16	9	9	14	..	5

The above data regarding *C. micropogon*, which has been referred to in the Australian literature on Australian blowflies as *C. dux* and as *C. megacephala*, constitute the first published information relating to the life periods of this species; they have been found to be practically identical with those of *C. albiceps*.

Our attention has been drawn by Dr. E. W. Ferguson to the fact that under the name *C. megacephala* there are in Queensland at least two species readily separable on examining the eyes, whose facets in one case (*C. micropogon*) are much smaller than in the other (*C. megacephala*).

R.S.—D.

TABLE 6.

No. of Specimens Bred.	Date of— Deposition.	Date of— Prepupation.	Date of— Pupation.	Date of— Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
			GENUS ANASTELLORHINA.						
			A. stygia Fabr.						
1	Aug. 16	Aug. 24	Aug. 31	Sep. 13	8	15	28	7	13
1	16	24	Sep. 1	15	8	16	30	8	14
			A. augur Fabr.						
4	Sep. 5	Sep. 11	Sep. 19	Sep. 30	6	14	25	8	11
11	5	11	19	Oct. 1	6	14	26	8	12
1	5	11	19	3	6	14	28	8	14
1	5	11	20	2	6	15	27	9	12
4	5	11	20	3	6	15	28	9	13
1	5	11	20	4	6	15	29	9	14
3	5	11	21	3	6	16	28	10	12
3	5	11	21	4	6	16	29	10	13
8	5	11	22	5	6	17	30	11	13
1	5	11	23	5	6	18	30	12	12
4	5	11	23	6	6	18	31	12	13
1	5	11	24	7	6	19	32	13	13
3	20	..	30	12	..	10	22	..	12
2	20	..	30	13	..	10	23	..	13
4	20	..	Oct. 2	13	..	12	23	..	11
1	20	..	2	14	..	12	24	..	12
3	20	..	3	14	..	13	24	..	11
6	20	..	3	15	..	13	25	..	12
2	24	..	7	18	..	13	24	..	11
3	24	..	7	19	..	13	25	..	12
1	24	..	8	19	..	14	25	..	11
11	24	..	8	20	..	14	26	..	12
5	24	..	9	20	..	15	26	..	11
1	24	..	9	21	..	15	27	..	12
18	24	..	11	21	..	17	27	..	10
33	24	..	11	22	..	17	28	..	11
4	24	..	11	23	..	17	29	..	12
2	24	..	12	22	..	18	28	..	10
20	24	..	12	23	..	18	29	..	11

TABLE 6—*continued.*

No. of Specimens Bred.	Date of— Deposition.	Prepupation.	Pupation.	Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
				A. augur Fabr.					
	Sept.	Sept.	Oct.	Sept.					
18	24	..	12	24	..	18	30	..	12
4	24	..	13	24	..	19	30	..	11
4	24	..	13	25	..	19	31	..	12
12	24	..	14	25	..	20	31	..	11
2	24	..	14	26	..	20	32	..	12
	Oct.	Oct.	Oct.	Oct.					
1	12	16	19	29	4	7	17	3	10
1	12	16	18	29	4	6	17	2	11
2	12	16	19	29	4	7	17	3	10
3	12	16	19	30	4	7	18	3	11
2	12	16	20	30	4	8	18	4	10
5	12	16	20	31	4	8	19	4	11
5	12	16	21	31	4	9	19	5	10
7	12	16	20	31	4	8	19	4	11
1	12	16	21	31	4	9	19	5	10
				Nov.					
6	12	16	22	1	4	10	20	6	10
1	12	16	20	1	4	8	20	4	12
10	12	16	21	1	4	9	20	5	11
2	12	17	21	1	5	9	20	4	11
21	12	16	22	2	4	10	21	6	11
1	12	17	22	2	5	10	21	5	11
7	12	16	23	2	4	11	21	7	10
1	12	17	23	2	5	11	21	6	10
28	12	16	23	3	4	11	22	7	11
2	12	17	23	3	5	11	22	6	11
44	12	16	24	3	4	12	22	8	10
41	12	16	24	4	4	12	23	8	11
51	12	16	25	4	4	13	23	9	10
1	12	17	25	4	5	13	23	8	10
35	12	16	25	5	4	13	24	9	11
4	12	17	25	5	5	13	24	8	11
16	12	16	26	5	4	14	24	10	10
1	12	17	26	5	5	14	24	9	10
1	12	16	25	6	4	13	25	9	12
23	12	16	26	6	4	14	25	10	11
4	12	17	26	6	5	14	25	9	11
13	12	16	27	6	4	15	25	11	10
1	12	16	26	7	4	14	26	10	12
23	12	16	27	7	4	15	26	11	11
2	12	16	28	7	4	16	26	12	10
9	12	16	28	8	4	16	27	12	11
1	12	16	28	9	4	16	28	12	12

The foregoing data regarding *A. stygia* constitute the first published detailed information regarding the life periods of this species.

The series of observations relating to *A. augur* show an extension of the limits already published regarding the species by Johnston and Tiegs. The larval period ascertained is identical, but the prepupa was found to range from two to 13 days, the pupa from 10 to 14 days, and the total period (deposition to emergence) 17 to 32. The minimum total period previously found was 19 days.

TABLE 7.

	Date of—				No. of Days From—				
No. of Specimens Bred.	Deposition.	Prepupation.	Pupation.	Emergence.	Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Disposition to Emergence = Total Period	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
	Sarcophaga beta J. and T.								
	Nov.	Nov.	Nov.	Nov.					
2	2	6	10	24	4	8	22	4	14
1	2	7	10	24	5	8	22	3	14
2	2	6	11	26	4	9	24	5	15
1	2	6	12	26	4	10	24	6	14
1	2	7	14	28	5	12	26	7	14
1	2	7	15	28	5	13	26	8	13
2	2	15	16	29	13	14	27	1	13
2	2	15	16	30	13	14	28	1	14
2	2	15	17	30	13	15	28	2	13
				Dec.					
1	2	15	18	1	13	16	29	3	13

The information given above constitutes the first published data regarding the life-cycle of this fly. A large female specimen, the identity of which was not known at the time, deposited fifteen larvæ in a tube within which it was confined, and into this tube was placed a piece of meat that was considered scarcely enough to allow the maggots to come to maturity, so that their development could be closely watched. On the fourth day all had reached their prepupal stage, but only five wandered away. The next day only three further specimens had left,

and seven remained in the tube in a torpid condition until the thirteenth day. As already mentioned, this observation indicates that maggots do not necessarily leave carrion as soon as they have reached their prepupal stage (*see also p.* 22).

TABLE 8.

No. of Specimens Bred.	Date of—				No. of Days From—				
	Deposition.	Prepupation.	Pupation.	Emergence.	Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
				Sarcophaga tryoni J. and T.					
	Sep.	Sep.	Sep.	Oct.					
1	10	20	22	9	10	12	29	2	17
8	10	20	22	10	10	12	30	2	18
1	10	20	23	9	10	13	29	3	16
8	10	20	23	10	10	13	30	3	17
5	10	20	24	11	10	14	31	4	17
2	10	20	24	12	10	14	32	4	18
		Oct.	Oct.	Oct.					
4	..	4	7	20	..	..	..	3	13
7	..	4	8	20	..	..	..	4	12
5	..	4	8	21	..	..	..	4	13
7	..	4	7	22	..	..	..	3	15
1	..	4	12	22	..	..	..	8	10
1	..	4	8	22	..	..	..	4	14
5	..	4	7	22	..	..	..	3	15
1	..	4	7	23	..	..	..	3	16
2	..	4	11	23	..	..	..	7	12
1	..	4	9	23	..	..	..	5	14
5	..	4	8	23	..	..	..	4	15
1	..	4	12	23	..	..	..	8	11
	Nov.	Nov.	Nov.	Nov.					
1	2	8	10	22	6	8	20	2	12
1	2	11	11	22	9	9	20	..	11
1	2	11	11	24	9	9	22	..	13
1	2	11	11	25	9	9	23	..	14
15	2	11	12	27	9	10	25	1	15
7	2	11	13	27	9	11	25	2	14
9	2	11	14	27	9	12	25	3	13
1	2	11	15	27	9	13	25	4	12
4	2	11	15	28	9	13	26	4	13
5	2	11	15	29	9	13	27	4	14
8	2	11	17	30	9	15	28	6	13
6	2	11	18	30	9	16	28	7	12
				Dec.					
1	2	11	19	1	9	17	29	8	12
1	15	21	24	7	6	9	22	3	13

TABLE 8—*continued.*

No. of Specimens Bred.	Date of— Deposition.	Prepupation.	Pupation.	Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
	Nov.	Nov.	Nov.	Dec.					
2	15	21	25	7	6	10	22	4	12
1	15	21	25	8	6	10	23	4	13
1	15	20	26	9	5	11	24	6	13
1	15	21	26	9	6	11	24	5	13
1	15	20	27	11	5	12	26	7	14
	Dec.	Dec.	Dec.	Jan.					
2	18	23	26	7	5	8	20	3	12
1	18	26	27	8	8	9	21	1	12
2	18	27	28	8	9	10	21	1	11
1	18	27	27	9	9	9	22	..	13
3	18	27	28	9	9	10	22	1	12
1	18	27	29	9	9	11	22	2	11
1	18	27	30	11	9	12	24	3	12
	Jan.	Jan.	Jan.	Feb.					
3	18	24	25	4	6	7	17	1	10
1	18	24	26	4	6	8	17	2	9
1	18	25	26	4	7	8	17	1	9
1	18	23	25	5	5	7	18	2	11
1	18	24	27	7	6	9	20	3	11
1	18	24	28	7	6	10	20	4	10
2	18	24	27	8	6	9	21	3	12
1	18	25	27	8	7	9	21	2	12
4	18	24	28	8	6	10	21	4	11
1	18	27	28	8	9	10	21	1	11
1	18	26	29	8	8	11	21	3	10
2	18	28	29	9	10	11	22	1	11
1	18	29	30	9	11	12	22	1	10
4	18	29	30	10	11	12	23	1	11
2	18	30	30	10	12	12	23	..	11
1	18	29	31	10	11	13	23	2	10
2	18	29	30	11	11	12	24	1	12
3	18	29	31	11	11	13	24	2	11
3	18	31	31	11	13	13	24	..	11
			Feb.						
1	18	29	1	11	11	14	25	3	11
7	18	31	1	13	13	14	25	1	11
1	18	31	1	15	13	14	28	1	14
		Feb.							
2	18	1	2	13	14	15	26	1	11
1	18	1	1	14	14	14	27	..	13
2	18	1	2	14	14	15	27	1	12
1	18	1	3	14	14	16	27	2	11
1	18	1	2	15	14	15	28	1	13
1	18	1	3	15	14	16	28	2	12

The stages previously determined for this large fly were only ascertained for the winter, and were recorded as larval feeding period 7 days, prepupal 7 to 8 days, and pupal as much as 7 weeks. The present contribution makes a distinct advance regarding our knowledge of the cycle of this species.

TABLE 9.

No. of Specimens Bred.	Date of—				No. of Days From—				
	Deposition.	Prepupation.	Pupation.	Emergence.	Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
SARCOPHAGA SPP.									
S. misera Walk.									
1	May ..	May 12	May 16	Oct. 13	..	..	..	4	150
1	Nov. 15	Nov. 21	Nov. 22	Dec. 2	6	7	17	1	10
1	15	21	22	4	6	7	19	1	12
3	..	..	Jan. 8	Jan. 17	..	..	..	..	9
17	..	..	8	18	..	..	..	..	10
2	..	..	9	18	..	..	..	..	9
7	..	..	9	19	..	..	..	..	10
1	..	..	10	19	..	..	..	..	9
2	..	..	10	20	..	..	..	..	10
1	Dec. 18	Dec. 27	Dec. 27	Jan. 6	9	9	19	..	10
1	Jan. 18	Jan. 26	Jan. 26	Feb. 3	8	8	16	..	8
3	18	24	25	4	6	7	17	1	10
1	18	24	26	4	6	8	17	2	9
1	18	25	26	4	7	8	17	1	9
S. eta J. and T.									
3	Dec. 18	Dec. 27	Dec. 28	Jan. 7	9	10	20	1	10
2	18	27	29	7	9	11	20	2	9

TABLE 9—*continued.*

No. of Specimens Bred.	Date of— Deposition.	Prepupation	Pupation.	Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
				S. peregrina R. D.					
1	..	May 10	May 15	May 28	..	..	..	5	13
1	..	10	15	Aug. 26	..	..	..	5	105
1	Jun. 2	Jun. 20	Jun. 23	27	18	21	86	3	65
1	2	20	23	Sep. 13	18	21	103	3	82
1	2	20	23	14	18	21	104	3	83
1	2	20	23	26	18	21	116	3	95
1	2	20	23	27	18	21	117	3	96
1	2	20	29	28	18	27	118	9	91
1	2	23	..	Oct. 4	21	..	124	..	106
				S. froggatti Tayl.					
3	Jan. 18	Jan. 26	Jan. 30	Feb. 9	8	12	22	4	10
4	18	26	31	10	8	13	23	5	10
2	18	26	31	11	8	13	24	5	11

The information given above constitutes the first published data regarding the life-cycle of *S. misera*, *S. eta*, and *S. froggatti* (Syn. *S. theta* J. & T.)

The observations regarding *S. peregrina* assist in filling certain gaps in the information contained in Johnston and Tiegs' paper.

TABLE 10.

No. of Specimens Bred.	Date of— Deposition.	Prepupation.	Pupation.	Emergence.	No. of Days From— Deposition to Prepupation = Larval Feeding.	Deposition to Pupation = Total Larval.	Deposition to Emergence = Total Period.	Prepupation to Pupation = Prepupal Period.	Pupation to Emergence = Pupal Period.
				Ophyra nigra Wiedemann.					
	Oct.	Oct.	Oct.	Nov.					
1	12	22	28	7	10	16	26	6	10
12	12	..	29	7	..	17	26	..	9
6	12	..	29	8	..	17	27	..	10
5	12	..	30	8	..	18	27	..	9
12	12	..	30	9	..	18	28	..	10
1	12	..	31	9	..	19	28	..	9
4	12	..	31	10	..	19	29	..	10
1	12	22	31	10	10	19	29	9	10
			Nov.						
5	12	..	1	10	..	20	29	..	9
1	12	22	2	10	10	21	29	11	8
1	12	22	1	11	10	20	30	10	10
2	12	..	1	11	..	20	30	..	10
1	12	22	2	11	10	21	30	11	9
1	12	..	2	11	..	21	30	..	9
4	12	22	2	12	10	21	31	11	10
2	12	..	2	12	..	21	31	..	10
5	12	22	3	12	10	22	31	12	9
2	12	..	3	12	..	22	31	..	9
1	12	22	3	13	10	22	32	12	10
4	12	..	3	13	..	22	32	..	10
1	12	20	4	13	8	23	32	15	9
2	12	..	4	13	..	23	32	..	9
6	12	20	4	14	8	23	33	15	10
2	12	..	4	14	..	23	33	..	10
1	12	..	4	15	..	23	34	..	11
1	12	22	6	15	10	25	34	15	9
2	12	..	6	15	..	25	34	..	9
4	12	22	6	16	10	25	35	15	10
1	12	..	6	16	..	25	35	..	10
1	12	22	7	16	10	26	35	16	9
4	12	22	7	17	10	26	36	16	10
1	12	22	8	18	10	27	37	17	10
1	12	..	13	24	..	32	43	..	11

This set of observations relates to that period regarding which Johnston and Tiegs' paper shows certain gaps. The larval feeding stage during October was 8 to 10 days, the prepupal 6 to 17, and the pupal (October-November) 8 to 10, while the total period elapsing between deposition and emergence was found to range from 26 to 43 days.

LITERATURE REFERRED TO.

1922. JOHNSTON AND TIEGS.—Notes on the biology of some of the more common Queensland Muscoid Flies. Proc. Roy. Soc. Queensland, xxxiv.. pp. 77-104.

A CORRECTION.

In our previous paper, these Proceedings, vol. xxxiv, 1922, the following lines should be erased:—

Page 192, last line

Page 193, first line.

New Cactus Bugs of the Genus Chelinidea (Hemiptera)

By JOHN C. HAMLIN, M.Sc., Officer in Charge, Prickly-pear Investigations, Commonwealth Prickly-pear Board.

(*Read before the Royal Society of Queensland, 28th May, 1923.*)

THE cactus bugs of the genus *Chelinidea* form one of the important groups of insects which are being introduced in the effort to control prickly-pear in Australia by biological agencies. During the past two years the writer has collected these insects extensively in North America with the result that two undescribed species and a new variety have been discovered. The new forms have been referred to in our work under the writer's manuscript names, but, in view of their economic status, it is highly desirable that their descriptions should be published.

Chelinidea hunteri n. sp.

Head subequal in length to pronotum, ocelli nearer to eyes than to pronotal collar, juga rather abruptly pointed and a very little exceeded by the tylus. Pronotum more convexed than in *C. vittigera*, lateral margins nearly straight from humeral angles to collar, anterior margin without teeth. Connexivum little dilated, extending only as a narrow edge beyond the hemelytra; hemelytra and connexivum forming straight parallel lines. Under surface of fore femora with from three to six teeth distally, arranged in two rows. Tibiæ merely carinate.

Ground colour faded yellow; head dark brownish or fuliginous with a paler indistinct vitta extending from over the tylus to base of the head, antennæ fuliginous except distal joint; pronotum with fuliginous transverse vittæ near front and rear margins; coriaceous portion of hemelytra mottled with rusty brown and smoky areas, the veins pale and bordered by thin lines of black; membrane blackish bronze; beneath, uniform greenish yellow, with legs a shade darker, and tip of rostrum piceous

Length 9·5 to 10·5 mm ; humeral breadth 3·5 to 4 mm.

Described from four male specimens collected by the writer on August 7th, 1922, at Ranchito, near Hermosillo, Sonora, Mexico, feeding on a cylindropuntia of the *Imbricatæ* series. Hunter *et al.* refers (Bur. Ent. Bull. 113, p. 20) to a small form found upon *O. arbuscula*, *O. versicolor*, and *O. fulgida* at Tuscon, Arizona (U.S.A.). There is little doubt that the above-described species is the same referred to by Hunter. The type material is in the writer's collection.

Chelinidea canyona n. sp.

Head and pronotum subequal in length ; ocelli nearer to extremities of pronotal teeth than to eyes, juga rather abruptly pointed and just attaining the tip of the tylus or very slightly exceeded by it. Pronotum appearing slightly concave ; the lateral margins elevated, forming distinct, laterally compressed crests which are curved upward ; anterior margin with a strong acutely pointed tooth on either side. Connexivum greatly dilated and inclined upward. Under surface of fore femora bearing distally two or three small teeth. Tibiæ triangular with all edges prominently elevated ; hind tibiæ with the two outer edges almost foliaceous. Penultimate ventral segment of female medianly cleft to two-thirds of its width, the edges of the incision slightly rounded and barely overlapping ; margins either side of notch very slightly concave.

Colour above rusty brown with darker markings. Head brown with a paler vitta on tylus extending to base of the head and bordered by shining black ; pronotum with a wide border of black just before the posterior margin, and very narrow ones along the lateral margins ; hemelytra with three dark bluish vittæ each, one along the outer margin and two oblique ones converging with the first proximally ; membrane black ; connexivum dark with segments indicated by pale lines ; beneath yellowish except pectus, bases of legs, and tip of rostrum, shining black ; legs brownish yellow except coxæ and bases of femora.

Length 11 to 14 mm. ; humeral breadth 4 to 4·5 mm.

Holotype, allotype, and paratypes are in the collection of the writer.

The writer first collected this species in the Rio Frio canyon, near Rio Frio, Texas (U.S.A.), in June 1921. Subse-

quently, it was taken generally over the canyon country north of Uvalde, Texas, but its distribution is apparently limited to the canyons. Its food is the prickly-pears of such regions. Since the above date I have constantly referred to it in my reports and correspondence under the manuscript name of *Chelinidea canyona.*

Chelinidea vittigera Uhler, var. **texana**, n. var.

This variety differs from the typical *C. vittigera* Uhler mainly in that the representatives are slightly less robust and that they lack the colour markings of the described form. The colour is uniformly testaceous, with membranous portion of hemelytra and tip of beak smoky black.

Length 10 to 13 mm.; humeral breadth 3 to 4·5 mm.

It is this form of *Chelinidea* which is the common cactus bug of Texas. In that State I have taken it at Kingsville, Brownsville, Laredo, San Antonio, Uvalde, La Pryor, Con Can, and Eagle Pass. In Mexico I have taken it in the country just south of Piedras Negras (Coahuila) and at Monterey (Nuevo Leon).

Besides the various Opuntias of the regions mentioned, I have occasionally found it feeding upon *Echinocereus* sp. ("pitallo") and *Opuntia leptocaulis* ("tasajillo").

Some Further Observations on the Dawson River Barramundi: *Scleropages leichhardtii.*

By THOS. L. BANCROFT, M.B.

(*Read before the Royal Society of Queensland, 28th May, 1923.*)

PROFESSOR T. Harvey Johnston, on my behalf, communicated to the Society a few curtailed notes on the Barramundi on 29th May, 1916,[1] to which this paper is supplementary.

The embryology of an ancient type of fish, such as *Scleropages*, is most important; so that any observations as to methods of obtaining material in the proper state to submit to embryologists are worthy of record. Perusal of these methods would obviate much waste of time and be of the greatest value to future scientific explorers. It used to be said that Barramundi would not mesh, but I found that was because nets of large mesh were not used, for with a six-inch mesh it is quite easy to take large fish, and even with a four-inch mesh fish up to four pounds in weight are readily meshed.

In my former paper I predicted that Barramundi might carry its ova in the mouth, and this has since been found to be so.

Not being able myself to go again to the Dawson I induced some young fellows who have a selection at Mostowie, the Squire brothers, to try to secure Barramundi with ova in the mouth. I supplied them with nets of various-sized mesh, one with a very small mesh suitable for dragging. Unfortunately the Dawson River, and likewise a large billabong on their selection in which Barramundi abound, are so full of fallen trees and snags that dragging a net is impossible. With set nets they found it quite easy to mesh the fish, but invariably, owing to the struggles of the fish captured in this way, any ova in their mouths are ejected. The Squire brothers, however,

[1] Proc. Roy. Soc. Q'land, vol. xxviii, p. 93.

on 21st October, 1922, shot with a rifle several Barramundi, the mouth of one of which was full of ova in various stages of development.

The best method to follow in securing ova and young forms would be to find a suitable spot on the Dawson to drag a net; a strong hemp net of three-inch mesh about fifty yards in length, with wings ten feet deep and a bunt eighteen feet, would, in my opinion, be the most suitable.

The facts so far obtained might be shortly expressed thus:—

1. Barramundi carries the spawn in its mouth.
2. October is the spawning season.
3. Fish when meshed eject the spawn.
4. Sexually mature fish are not meshed in a net of three-inch mesh.
5. Fish secured in the bunt of a drag-net would retain the ova and young fish in their mouths.

On 12th November, 1922, whilst dragging a net in the Burnett River, a Salmon Catfish, *Hexanematichthys australis*, was taken with ova in its mouth. This fish is uncommon in the Burnett but extremely plentiful in the Dawson River; the latter river would be the place to go if ova of this fish were required.

An Unusual Tourmaline-Albite Rock from Enoggera, Queensland.

By W. H. BRYAN, M.Sc.,
Lecturer in Geology and Mineralogy, The University of Queensland.

(Plate II.)

(*Read before the Royal Society of Queensland, 28th May, 1923.*)

(I) INTRODUCTION.

THE remarkable rock which forms the subject of this paper was discovered in the year 1914 by the author on the Cedar Creek road, between portions 313 and 314, parish of Kedron, about 7 miles north-west of the City of Brisbane, in the State of Queensland.

The only previous record of this rock is a short reference in the author's "Geology and Petrology of the Enoggera Granite and Allied Intrusives, Part I".[1]

(II) FIELD OCCURRENCE.

The rock to be described forms a band about two feet in thickness some 25 yards outside the contact of the "Enoggera Granite" (of Permian age) with the Brisbane Schist (? Ordovician). This band can be traced for fifty yards in a

[1] Proc. Roy. Soc. Qld., vol. xxvi, 1914, p. 153.

N.N.W. direction, which is the normal strike of the Brisbane Schists, and is, further, the most important trend line in the Brisbane area. This agreement in direction may, however, be merely coincidental, for the schists twenty yards further from the contact strike E.N.E. (*i.e.*, roughly parallel with the edge of the granite laccolite at this point), and dip to the N.N.W., while between the tourmaline-albite rock and the contact the strike is very erratic.

The appearance of the rock in the field s very beautiful and striking, being black in colour with numerous irregular sinuous and contorted veins of a light-coloured material standing out in marked relief. A few feet away on either side an identical structure can be seen where numerous tortuous veins of quartz are threaded through the normal mica schists.[2] The field evidence leaves no doubt that, however the mineralogical nature of the tourmaline-albite rock be explained, the schistose structure is that of the Brisbane Schists themselves.

Nearer the granite and almost on the contact is a large body of massive schorl rock composed almost entirely of tourmaline identical with that in the tourmaline-albite rock but in which only traces of the schistosity remain. These traces sometimes take the shape of numerous irregular roughly parallel but empty veins. This rock contains, in addition, cavities which are partly or almost completely filled with well-shaped quartz crystals and an occasional crystal of pyrites. Small patches of tourmaline are also found in the schist over fifty yards from the contact.

These tourmaline rocks cannot be considered as in any way representative of the contact effects of the Enoggera Granite on the schists.[3] The Brisbane Schists outside the contact zone are in this locality a series of schistose and phyllitic rocks, consisting for the most part of mica, through which run numerous irregular veins of quartz, which follow the plications and thus emphasize the schistose character of the rock. The normal effect of the intrusion of the granite at this point is to produce in these schists a recrystallization of both mica and quartz, but no new minerals seem to have been added.

[2] *See* Richards, "A Study of the Brisbane Schists," Inst. of Engineers, Brisbane Divn., June 1922, p. 5.

[3] *See* Bryan, 1914, op. cit., p. 152.

(III) DESCRIPTION OF ROCK.

Megascopic.—In the hand specimen the rock appears to be made up entirely of black tourmaline and creamy pink felspar. The tourmaline, which consists of a matted aggregate of minute prismatic crystals, is the more abundant mineral, and forms a black background against which the light-coloured felspar stands out in high relief as a series of crumpled, contorted bands of varying thickness. The individual bands are sometimes persistent, but are often pinched out and discontinuous. They vary in width from 2 mm. to barely discernible threads.

Microscopic.—Microscopic inspection confirms the general impressions gained in an examination of the hand specimens. The rock is seen to consist almost entirely of tourmaline and felspar.

The tourmaline forms a matted aggregate of prismatic crystals averaging about 0·15 mm. in length and 0·03 mm. in breadth, and of fairly uniform size.

In transmitted light the colour is bluish green. Absorption is strong and characteristic (O>E) and the dichroism is marked, O being dark bluish green, and E light brown with a greenish tint. All of the tourmaline crystals appear to be of the one type and no colour zoning is apparent in individuals.

The felspar is albite, with typical double refraction and low refractive index. Polysynthetic twinning is commonly present both on the Albite and Pericline law, both types being sometimes displayed on the one crystal. The twinning is somewhat irregularly developed and sometimes gives rise to a structure which may be compared with the "Chequer" structure of albite described by Flett,[4] Hughes,[5] and Tilley.[6]

The felspar crystals contain numerous minute inclusions.

The junction between the tourmaline and felspar is well defined. A few crystals project into the felspar, and occasional isolated crystals are seen enclosed in the felspar itself, but the general nature of the contact militates against the view that the tourmaline has been formed at the expense of the albite. The general structure suggests that the albite is a later mineral

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[4] "The Geology of Newton Abbot," 1913, p. 60.

[5] "The Geology of Part of Carnarvonshire," Geol. Mag., 1917, p. 18.

[6] Proc. Roy. Soc. S. Aus., 1919, p. 328 also Pl. xxxi, fig. 2.

than the tourmaline, and has occupied sinuous cavities or replaced veins in the tourmaline rock. The size of the felspar crystals is variable, but usually one individual occupies the whole width of the vein.

In addition to the veins, however, smaller crystals of felspar occur in the heart of the matted tourmaline.

In other cases, particularly in the smaller veins and along portions of the margins of the larger, the felspar is present as groups of small crystals.

(IV) CHEMICAL.

In order to further investigate the nature of the minerals of the tourmaline-albite rock, quantitative chemical analyses were decided on. Part of one of the felspar bands was carefully removed, piece by piece, from the rock. This felspathic material was then ground very finely, and all traces of tourmaline removed by a powerful electro-magnet. In this way a small amount of the felspathic material was obtained in a fairly pure state. This was analysed by Mr. G. R. Patten in the laboratory of the Queensland Agricultural Chemist, with the result shown in the first column of Table 1.

In order to provide the analyst with a larger quantity of material for the more difficult analysis of the tourmaline, a sample of the massive tourmaline from the edge of the granite was sent in preference to that which had been separated from the tourmaline-albite rock. The mineral submitted appears to be identical with that of the tourmaline-albite rock in colour, size and habit of crystals, and general appearance. The sample forwarded was seen to contain, however, as an impurity a considerable quantity of small red crystals of hæmatite. Consequently particular care was exercised by Mr. Patten in the determination of ferric and ferrous iron.

The resulting analysis showed 7·43 per cent. of Fe_2O_3 out of a total of 99·95. This was assumed to be present in the form of hæmatite, and was consequently subtracted from the total, which was then recalculated to 100 per cent., with the result set out in the second column of Table 1.

As a matter of interest, two further analyses appear in Table 1. These are analyses of the Brisbane Schist and of the Enoggera Granite (Pink Phase) respectively. Neither of

these analyses was made for the purpose of this paper, and neither is of rocks found in the immediate neighbourhood of the tourmaline-albite rock, so that no quantitative arguments could be safely based upon them.

Of these analyses, No. 3 is that of a typical example of Brisbane Schist from the city of Brisbane. The Brisbane Schists are known to be made up of various types of altered rocks, but by far the greater part is micaceous schist, of which the analysis (3) should be quite representative. The Brisbane Schists in the locality under discussion are represented by very similar micaceous schists, so that the analyses quoted may give a general indication as to their chemical composition.

Analysis No. 4 is that of a rock selected by the author as typical of the Pink Phase of the Enoggera Granite, and may be considered as a fairly safe guide to the chemical composition of the granite, which has all the mineralogical characteristics of the Pink Phase at this point.

TABLE 1.

—	1.	2.	3.	4.
SiO_2	63·40	36·51	61·62	73·52
Al_2O_3	24·99	33·13	21·20	11·05
Fe_2O_3	1·61	..	1·51	Nil
FeO	0·28	10·30	1·93	3·15
MgO	0·37	5·23	1·77	1·03
CaO	0·42	1·58	1·59	1·70
Na_2O	8·57	2·14	3·39	4·08
K_2O	0·35	0·15	3·07	3·99
$H_2O +$	..	0·43	3·29	0·44
$H_2O -$	..	..	3·03	0·16
TiO_2	Nil	0·92	0·92	0·20
P_2O_5	..	0·18	0·17	0·15
MnO	tr.	0·40	0·07	..
Br_2O_3	..	9·03	..	..
Total	100·12	100·00	100·56	99·48

Analysis 1 = Albite in Tourmaline-Albite rock. Analyst, G. R. Patten.

Analysis 2 = Tourmaline in Tourmaline-Albite rock. Analyst, G. R. Patten.

Analysis 3 = Brisbane Schist. Analyst, G. R. Patten.

Analysis 4 = Enoggera Granite (Pink Phase). Analyst, G. R. Patten.

An examination of Analysis 1 shows that the felspar present is undoubtedly albite, but a consideration of the

relative proportions of soda, silica, and alumina shows that there is a considerable excess of the two latter. By using Harker's or Osann's tables we can easily calculate that the proportions of these three oxides in albite are very different from the ratios shown in the chemical analysis.

Ratio in Albite.	Na_2O.	Al_2O_3.	SiO_2.
Actual	8·57	24·99	63·40
Calculated	8·57	14·15	49·74
Excess	..	10·84	13·66

It is difficult to explain this very large excess, even after the other bases have been allowed their quotas of silica and alumina. The presence of andalusite and quartz suggested itself, but search for these minerals proved fruitless. Possibly many of the minute inclusions observed in the albite may be quartz and andalusite, but these could not nearly account for the large excess of silica and alumina. The conclusion was forced on one that the silica and alumina were present in solution in the albite in spite of the fact that Foote and Bradley investigated this very problem and came to the conclusion that "no solid solution of quartz, corundum or nephelite in albite occurs which is greater than the apparent variation in composition due to the ordinary errors of analysis."[7]

The excess of silica, anomalous though it seems, serves to explain in part another anomaly seen in the rock itself—viz., the absence of quartz in a tourmaline rock which (the structure suggests) has been formed by replacement.

Turning now to the second analysis, we find it quite normal except in t e low percentage of water present.

(V) DISCUSSION.

(A) Mineralogical.

Mineralogically the rock, consisting as it does almost entirely of tourmaline and albite, is almost unique. Only one

[7] Foote and Bradley, "Constant Composition of Albite," Am. Jour. Sc., xxxvii, 1913, p. 47.

other rock showing this curious association has been described. Concerning this, Dr. J. S. Flett writes as follows :—" *Tourmaline-Albite Rocks*.—In two places within this sheet (347) rocks have been found belonging to a class which has not hitherto been described. They consist of tourmaline and albite, and are undoubtedly altered states of the killas or clay slates, seeing that they retain the banding and slip-cleavage which the killas alone displays." The albite occurs as " a colourless mineral in the clear bands of the rock." Further, " it forms grains of very small size and very irregular shape, which seldom show twinning of any kind. The tourmaline is in small prisms which have brown and bluish green colour." [8]

Dr. A. Harker, F.R.S., to whom a specimen of the Enoggera rock was sent, writes to the author concerning it, as follows :— " The tourmaline-albite rock is interesting, and is apparently a rare type. The only other occurrence known to me is on the border of the St. Austell granite, in Cornwall, and has been briefly described by Flett in the Survey Memoir (Geology of Bodwin and St. Austell). I collected and sliced this Cornish rock some years ago, when Benson and I visited the district. It differs somewhat from yours, the albite being in little clear untwinned granules, easily mistaken for quartz, and the little prisms of tourmaline having a more pronounced parallel arrangement." This communication from the eminent petrologist is especially important, since Dr. Harker alone has had the advantage of handling the specimens from both Cornwall and Queensland.

The presence of tourmaline in localised patches (usually associated with quartz) in rocks intruded by a granite magma is, of course, quite a common phenomenon, and can in most cases be readily explained, but the presence of albite in such rocks is a matter which seems to admit of more than one explanation. The mineral may be original, it may be a product of metamorphism of pre-existing minerals, or it may have been introduced by the granite magma.

With respect to the last possibility, the evidence is somewhat conflicting; for, although petrologists were, as the result of a great weight of evidence, forced to the conclusion that a transfer of soda from the invading to the invaded mass

[8] Petrological Notes in " The Geology of Bodmin and St. Austell," 1909, p. 103.

has frequently taken place where the former is a basic rock, such transfer was not admitted in the case of granitic intrusions.[9] Allport, as early as 1876, in discussing the altered Cornish slates. pointed out that of the minerals of the granite "schorl, two varieties of mica, quartz, and felspar," "felspar is the only one absent from the altered slates."[10] He was obviously unaware of the tourmaline-albite rock later described by Flett.

In 1887 Rosenbusch,[11] as a result of his work on contact phenomena in the Vosges, decided that nothing except a little boric acid had actually been added to the schists. In 1881 G. W. Hawes,[12] in describing the contact phenomena of the Albany granite, concluded that the addition of soda to the invaded strata "may be regarded as certain." In 1886 Bonney[13] pointed out that the differences between schists of regional metamorphism on the one hand and contact metamorphism on the other lay "chiefly in the presence of felspar" in the former.

In 1894 Hutchings[14] emphasized the fact that soda was transferred from basic intrusions but not from acid, but as the result of further work he came to the conclusion, in the following year, that soda almost certainly was introduced from *granitic* masses.[15]

The albitites of Tilley[16] and many pegmatites also force one to the conclusion that albite is a mineral which may be formed as the result of pneumatolytic, hydatogenetic, or deuteric processes, not only in basic but also in acid rocks, and as such may be expected in the metamorphosed rocks about a granitic intrusion.

Flett assumes that the albite in the Cornish rock has not been introduced by the granite, for he writes: "The abundance of albite leads us to correlate these rocks with the felspar hornstones of the calc-flintas series, and they may represent

[9] *See* especially Roth, Chemische Geologie, vol. iii, 1893.

[10] Q.J.G.S., 1876, p. 408.

[11] Die Steiger Schiefe und ihre Contact zone, 1877, p. 257.

[12] Amer. Jrnl. Sci., 1881, p. 28.

[13] Pres. Add. Q.J.G.S., 1886, p. 104.

[14] Geol. Mag., 1894, p. 74.

[15] Geol. Mag., 1895, p. 165.

[16] Proc. Roy. Soc. S. Aus., 1919, p. 334.

tourmalinised states of these hornstones." Further, he writes that the specimens "show that albite is more resistant to pneumatolytic emanations than mica, as all the mica has disappeared, and this is in accordance with the frequency of albite in the china stones and kaolinised granites."[17]

One cannot assume in the present problem the presence of bands of albite in the unaltered schists, felspars in this rock being conspicuous by their absence, and must conclude that the albite is the result of contact metamorphism, and has either been formed by the recrystallization of the minerals already present in the rock or that it has been introduced from the granite magma just as the tourmaline was. The chemical evidence, such as it is, favours the former view, but it were safer to disregard this evidence altogether, for the analysis on which it is based is that of a sample of Brisbane Schist some miles distant. The field evidence and structure of the rock are decidedly in favour of the latter alternative; and they suggest, further, that the tourmaline albite rock was formed in two stages, which, however, may have followed each other very closely. The first stage was the tourmalinisation of the micaceous part of the schist and the expulsion of the excess silica together with that of the quartz veins. This silica was subsequently redeposited in druses, such as are found in the neighbouring massive tourmaline rock which represents a part of the schist which was affected by this first stage only.

The second stage saw the deposition of albite from hot aqueous solutions along the planes vacated by the quartz.

(B) Structural.

The writer has found a number of descriptions, some of them illustrated by plates and figures, of tourmaline contact rocks, with structures very closely resembling that of the Enoggera rock. In some of these cases the schistose structure seems to be independent of, and in other cases the direct result of, the intrusion of the granite. Dr. Bonney[18] has urged that foliated rocks of the latter type should not be termed "schists," and agrees with Sir A. Geikie in the suggested revival of Dr. Boase's old name "cornubianite," but has re-defined it as "essentially consisting of quartz, mica, and

[17] Op. cit., 1909, p. 103.

[18] Op. cit. Note to p. 104.

tourmaline." Teall points out that this is "approximately equivalent to the tourmaline hornfels of Continental petrographers."[19] He also states that "the term hornfels is used by many writers as a general name for the innermost zone in regions of contact metamorphism, and thus applied even to schistose and banded rocks."[20]

A classic example of tourmaline "schists," in which the schistosity is the direct result of contact metamorphism, is that described from Cornwall by Allport in 1876,[21] where the "original lamination of the fine sedimentary matter has been replaced by a distinct foliated texture." He adds: "It should be stated, however, that a decided foliation is restricted to the immediate vicinity of the granite." In describing the contact effects on the Mylor slates, Reid and Flett state: "Close to the granite and within the zone into which granite veins extend the slates become much twisted, gnarled, and knotted, are often full of tourmaline, and the gaps between the twisted laminæ have been filled up with streaks and lenticles of quartz of schorl rock or of chlorite."[22] These authors also describe the formation of "muscovite-tourmaline schist with quartz from phyllites by heated solutions from the invading granite."

It seems that the effect of contact metamorphism on such rocks as slates and schists may be either to obliterate the schistosity or to greatly accentuate it, and both these types of alteration can be observed about the edge of the Enoggera granite. Rosenbusch has described a "tourmaline hornfels, schistose in structure," composed of tourmaline, staurolite, white mica, and quartz from the clay slates of the Vosges, but he points out that in contact rocks in this area the schistose structure is exceptional, and that as the innermost zone is approached all schistosity vanishes from the rocks and they become massive in character.[23]

Means, in describing tourmaline-bearing quartz veins from Ontario,[24] speaks of "narrow bands of highly altered country rock embedded in quartz," and consisting of "a

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[19] British Petrography, 1888, p. 386.

[20] British Petrography, 1888, p. 375.

[21] Op. cit., Pl. xxiii, fig. 6.

[22] "The Geology of the Land's End District," p. 9.

[23] Quoted from Teall, op. cit., p. 375.

[24] Economic Geology, 1914, p. 129.

highly tourmalinised schist" made up of "fine needles of tourmaline set in a matrix of fine crystalline muscovite." These bands, beyond doubt, represent fragments of very highly altered country rock "which was probably a diorite or a chlorite schist," and which was "first in part made schistose by dynamic metamorphism."

The rock which most nearly approaches in structural characters the Enoggera rock seems to be that described by Flett[25] from Cornwall as "tourmalinised slate (E 1759), Belovely Beacon," a microphotograph of which is shown and which is described as "a secondary aggregate of quartz and schorl which has replaced the original slate," and in which "the cleavage and slip-cleavage of the slates are perfectly retained."

The writer has in an earlier section commented on the remarkable similarity in structure between the albite-tourmaline rock of the Enoggera area and the unaltered Brisbane Schist. In 1914 he wrote: "The whole schist has been so beautifully replaced that the new rock under the closest scrutiny shows every characteristic of the normal schistose structure."[26] As the result of further investigation he sees no reason to modify that statement. The schistosity shewn in this interesting contact rock is undoubtedly older than and for the most part independent of the contact metamorphism.

(VI) CONCLUSION.

1. The rock described is almost on the contact of the Enoggera Granite with the Brisbane Schist.

2. Mineralogically it is almost unique, consisting as it does almost entirely of tourmaline and albite.

3. Practically no quartz is present, but a chemical analysis of the albite shows remarkable excesses of both silica and alumina.

4. Structurally the rock is remarkably like the unaltered Brisbane Schists, the tourmaline of the altered rock corresponding in position and amount with the micaceous part of

[25] Petrological Notes in "The Geology of Bodmin and St. Austell," 1909, p. 187.

[26] Op. cit., 1914, p. 153.

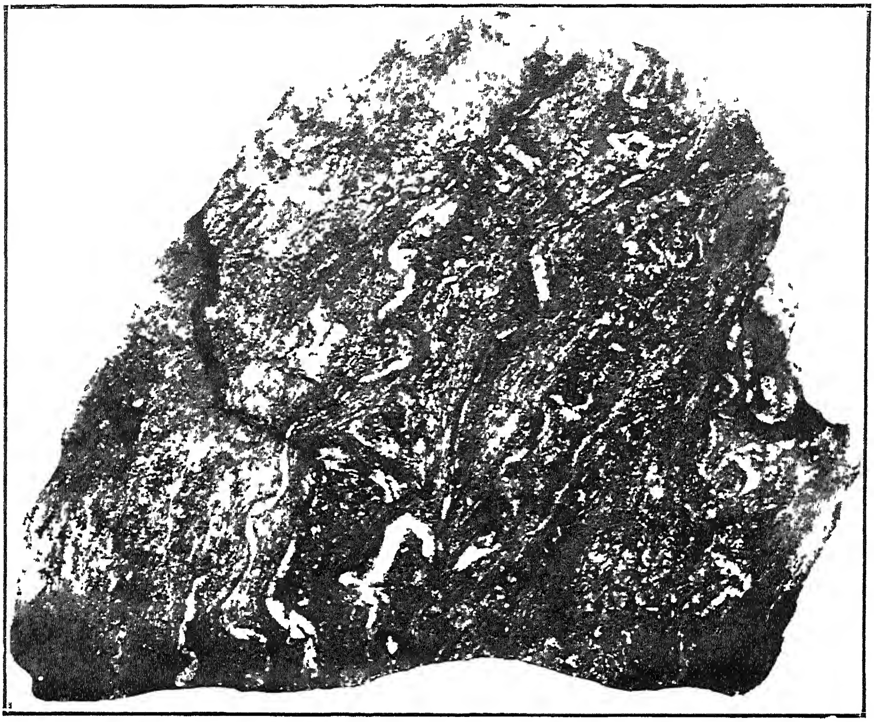
the unaltered schist, while the felspar veins of the former correspond in number and type with the quartz veins of the latter.

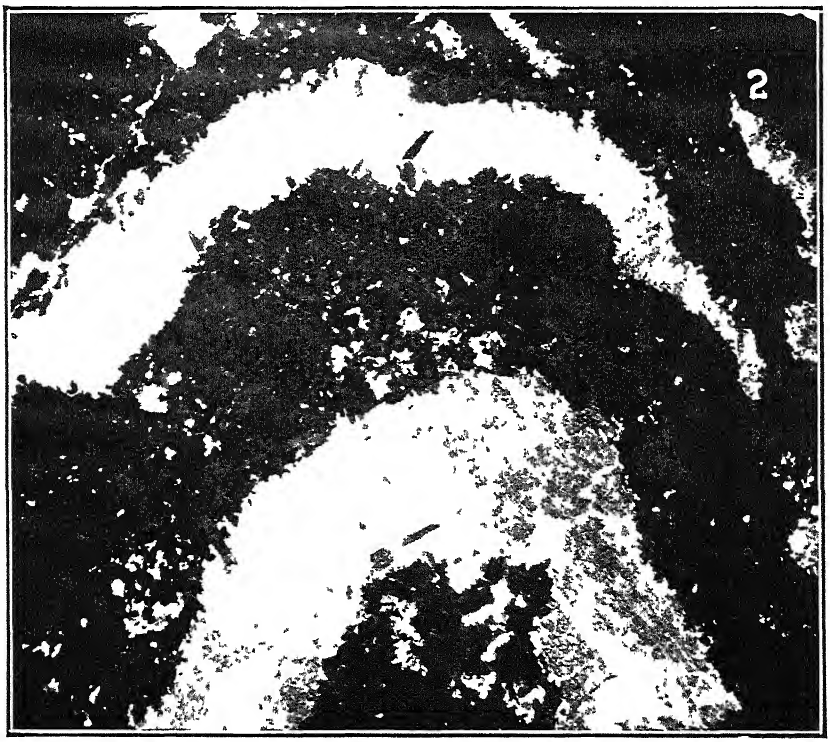
5. In order to explain (I) the association of tourmaline and albite, (II) the absence of free quartz, and (III) the structural nature of the rock, the following hypothesis is advanced :— The micaceous parts of the schist have been metasomatically replaced by tourmaline, and the excess silica, together with that of the quartz veins has been removed to be redeposited elsewhere. Following this alteration, albite was introduced from the granite and deposited among the veins vacated by the quartz and in any interstices in the matted tourmaline.

PLATE II.

Figure 1.—Photograph of polished specimen of Tourmaline-Albite rock found replacing Brisbane Schist near its contact with the Enoggera Granite. Approximately natural size.

Figure 2.—Microphotograph of same rock in ordinary transmitted light. ×18.

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Notes on the Essential Oils of Daphnandra aromatica.

By T. G. H. Jones, B.Sc., A.I.C., and Frank Smith, B.Sc., F.I.C.

(Read before the Royal Society of Queensland, 27th June, 1923.)

Daphnandra aromatica (N.O. Monimiaceæ) is distinguished from other of the genus by its aromatic bark and slightly fragrant leaves.

Parcels of the leaves and bark, collected for us by courtesy of Mr. E. H. F. Swain, Director of Forests, were submitted to distillation in high-pressure steam, and the small amounts of oil collected have permitted of determination of their general character.

OIL OF THE BARK.

One hundred and forty-five pounds of the dry bark yielded 200 cc. (·3 per cent.) of a dark amber oil, heavier than water, and possessing the characteristic odour of the bark, predominantly that of sassafras.

The following constants were recorded:—$a\frac{15}{15}$ 1·077; $[\alpha]_D - 1{\cdot}9$, $[n]_{D20}$ 1·525.

Acid, ester, and acetyl values, nil.

Nothing was extracted from the oil by alkali bisulphites, and a trace only of phenolic body by caustic alkali.

When placed in a freezing mixture the oil became almost completely solid.

Fractionation of 150 cc. of 130 mm. pressure gave 4 cc. at 70-80° C., 4 cc. at 80-128° C., and 140 cc. at 129-130° C.

The last fraction, constituting the bulk of the oil, possessed the characteristic properties of almost pure safrol, $[n]_{D25}$ 1·0530, $a\frac{15}{15}$ 1·096, $[\alpha]_D - {\cdot}5$; and was confirmed as such by preparation of piperonylic acid, its oxidation product.

Safrol, which constitutes about 95 per cent. of the bark oil of *D. aromatica*, is also, among the Monimiaceæ, the principal constituent of laurel leaf oil,[1] and has been identified

[1] Gildemeister and Hoffmann, "The Volatile Oils."

in the leaf oil of *Atherosperma moschatum* (Victorian sassafras).[2] Its occurrence in the volatile oils of the Lauraceæ is common, notably in those of the Cinnamomums. The bark oil of *C. Olivieri* (Brisbane sassafras) contains 25 per cent.[3]

The lower fraction (4 cc.) was not sufficient in amount for identification of the optically active constituent, probably a terpene the general characteristics of which indicated it to be lævo-rotatory pinene.

THE OIL OF THE LEAF.

The yield from the air-dried leaves was approximately ·3 per cent. The essential oil was light greenish yellow in colour, and possessed an odour faintly resembling cinnamon. Its constants were—$\alpha\frac{15}{15}$ ·9181; $[\alpha]_D + 33{\cdot}7$; $[n]_{D20}$ 1·489. Ester value 20; acetyl value 50.

Sodium bisulphite solution extracted 2-3 per cent. of a body which was apparently not cinnamic aldehyde; and caustic potash solution, ·5 per cent. of a phenol giving a bluish green colour with ferric chloride.

On fractionally distilling the amount of oil available (45 cc.) under 30 mm. pressure it was resolved into two principal fractions, viz.:—(1) Boiling at 70-80° C., and (2) at 145-154° C.

The lower fraction possessed $[n]_D$ 1·478 and α + 54·2 in a 1-dcm. tube. Its odour and general characteristics indicated the presence of limonene, though the amount of the fraction was insufficient to permit of purification and identification.

The behaviour on fractionation would show that the principal constituents of the leaf oil are a terpene (d-limonene ?) or terpenes, and a body, probably a sesquiterpene, comprising the bulk of the last fraction, $[n]_D$ 1·501, amounting to about 50 per cent. of the whole oil.

It is hoped to further elucidate the composition of the leaf oil of *D. aromatica* when a larger quantity of material is available.

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[2] M. E. Scott, J.C.S. 101 (1912), 1612.

[3] G. W. Hargreaves, J.C.S. 109 (1916), 751.

Contributions to the Queensland Flora.

No. 2.*

By C. T. WHITE, F.L.S., Government Botanist, and
W. D. FRANCIS, Assistant Government Botanist.

(Text-figures 1–9.)

(Read before the Royal Society of Queensland, 24th July, 1923.)

ORDER CRUCIFERÆ.

Cakile maritima Scop. Collected on the ocean beach, Stradbroke Island, Moreton Bay, by C. T. White. This herb, which is found in Europe, South Africa, and South America, is also common on the sea beaches of New South Wales. This is the first record of its occurrence in this State.

ORDER PITTOSPORACEÆ.

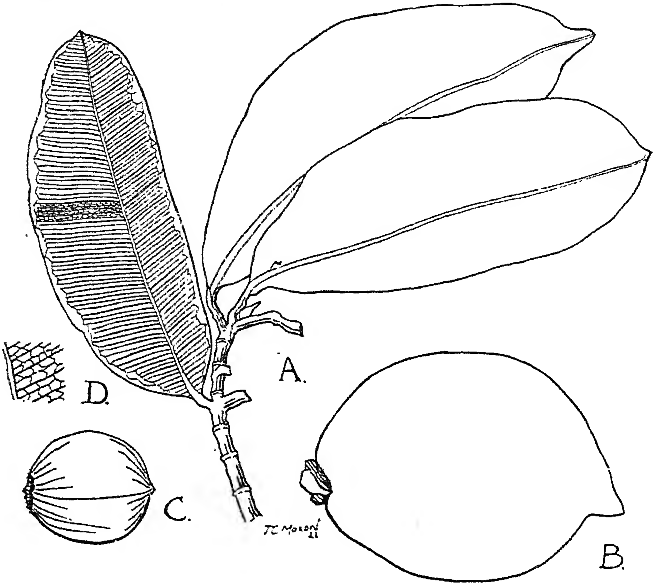
Hymenosporum flavum F.v.M. Some specimens of this tree were recently received from Ravenshoe collected by Mr. J. B. Manuell and from the parish of Barron collected by Mr. D. Fraser, both localities on the Atherton tableland, North Queensland. The specimens differ from the more commonly known form in the under surface of the leaves, the peduncles and pedicels being more hairy. The fruits also are covered with a loose, floccose tomentum. The tree is common on the Eungella Range, North Queensland, and herbarium specimens from there are similar to Southern ones. It has also been recorded from Rockingham Bay by Mueller (Fragm. Phytogr. Austr. v. 210 and vi. 168).

ORDER GUTTIFERÆ.

Calophyllum touriga sp. nov. Arbor magna; ramulis glabris subteretibus; foliis modice petiolatis (petiolis ca. 1·3 cm. longis) coriaceis glabris ellipticis prominente pellucido-punctatis (12-18 cm. longis, 5-8 cm. latis); inflorescentiis floribusque ignotis; fructibus magnis (ad 10 cm. longis) ovoideo globosis obliquis apice acutis; seminibus globosis (ad 2.5 cm. diam.).

* No. 1 in vol. xxxiii., 1921, pp. 152-165.

A rain forest tree attaining over 100 ft. (30 m.) in height. Barrel not flanged at base, bark scaly. Apparently glabrous. A branchlet 4 in. (10 cm.) long measures 2 lines (4 mm.) in diameter at base. At intervals and frequently between the



Text-figure 1.

Calophyllum touriga sp. nov. A, leafy shoot. B, fruit. C, seed. All about half natural size. D, portion of leaf showing venation, $\times$ 3/2.

insertions of the leaves the young branchlets are marked by transverse cicatrix-like rings. Leaves elliptical, obtuse or rounded or shortly acuminate at the apex, entire, coriaceous, margins recurved, lateral nerves close, parallel and almost tranverse, ·5-1 mm. apart; measurement of leaves 4½-7 in. (12-18 cm.) long, twice to three times as long as broad; petioles about ½ in. (1·3 cm.) long, prominently grooved on the upper side. No flowers available. Fruit large, apparently subtended by five orbicular calyx lobes, exuding a milky juice when cut, globular-ovoid, oblique, apex pointed, slightly narrowed at the base, attaining 4 in. (10 cm.) in length, endocarp in dry or partially dry fruit crustaceous, about ·5 mm. thick. Seed globular, about 1 in. (2·5 mm.) in diameter. (Text-figure 1.)

Hab.: Bellenden-ker Range, at altitudes of 2,000-3,000 ft., C. T. White; Boonjie, D. Fraser; Gourka Pocket, Atherton Tableland, A. L. Merrotsy (fruiting specimens, January, 1923).

This tree, which is very plentiful in the localities enumerated, has a bark with a general resemblance to that of the Bolly Gum, *Litsea reticulata*. The timber is durable and is extensively used on farms for fencing posts and rails and for purposes in which hardwood is generally used. It also resembles the timber of *Litsea reticulata*, but is darker in colour and heavier in weight.

ORDER MALVACEÆ.

Abutilon crispum G. Don. Syst. i., 502. Collected at Bowen by Rev. N. Michael. This Indian and tropical and sub-tropical American plant was previously unrecorded for the State.

ORDER STERCULIACEÆ.

Helicteres Isora Linn. Collected on Settlement Creek, North-west Queensland, by L. Brass. An Asiatic plant only previously recorded in Australia from the Northern Territory.

ORDER TILIACEÆ.

Corchorus olitorius Linn. Collected on the Landsborough and Flinders Rivers of Central and North Queensland by C. T. White. A tropical Asiatic plant previously unrecorded for the State.

Elæocarpus eumundi Bail. The flowers of this species, which was named and described from fruiting specimens, have not been described previously. Following is a description of them :—

Racemes secund, arising from the scars of fallen leaves sometimes at a distance of 10 in. (25 cm.) below the apex of the branchlets; rhachis, pedicels, sepals, and petals silky pubescent; rhachis about 2 in. (5 cm.) long; pedicels slender, 4-6 lines (8-12 mm.) long; flowers pale or greenish yellow; sepals 5, narrow linear, acuminate, margins incurved, 4-5 lines (8-10 mm.) long; petals 5, oblong, 5 lines (10 mm.) long, divided at the apex for about one-fourth of their length into about 20 linear lobes; disc evenly and finely 10-toothed, glabrous; stamens about 30, puberulent; filaments about 1 line (2 mm.) long; anthers narrow linear, about 2 lines (4 mm.) long, one of the two apical points recurved and exceeding 1 line (2 mm.) in length; ovary ovoid, glabrous; style slender, glabrous, 4-5 lines (8-10 mm.) long.

Hab.: Flowering specimens collected Dec. 1922, at Fraser Island, by F. C. Epps.

R.S.—F

ORDER RUTACEÆ.

Boronia granitica Maid. & Betche, Proc. Linn Soc. N.S.W. vol. xxx., 357 (1905). This shrub, which was first found at Emmaville, N.S.W., has now been collected at Stanthorpe, Queensland, by Alex. Macpherson, W. R. Petrie, and E. W. Bick.

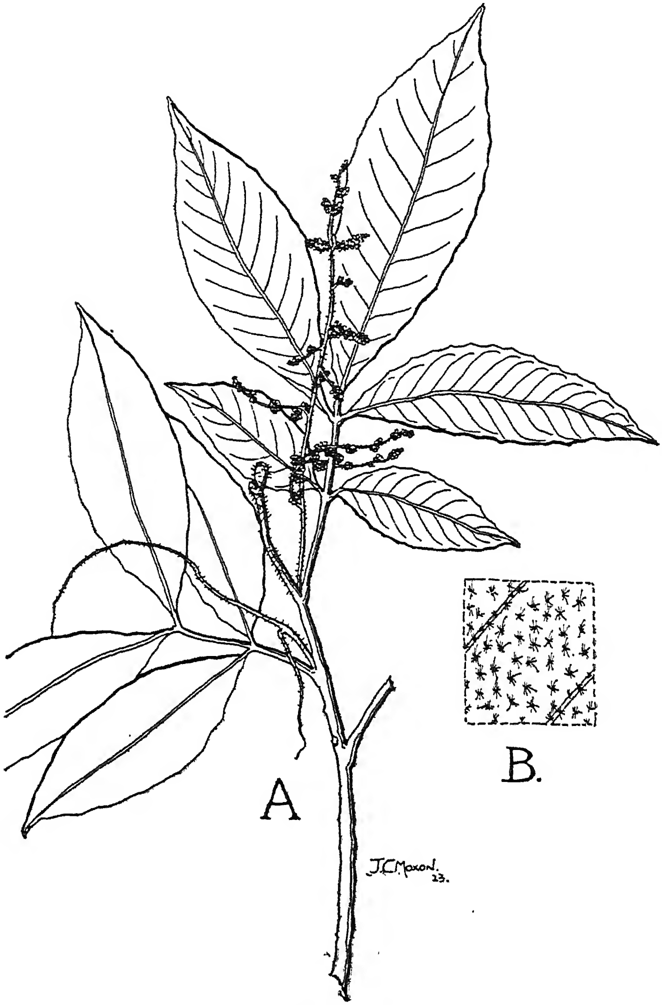
ORDER MELIACEÆ.

Aglaia ferruginea sp. nov. Arbor ramulis juvenilibus dense rufo-pubescentibus; foliis longe petiolatis impari-pinnatis, 2-jugis, petiolo communi et rhachide stellato-pubescentibus ferrugineis, foliolis breviter petiolulatis submembranaceis ellipticis vel oblanceolatis acuminatis, paniculis axillaribus ramulis stellato-pubescentibus; floribus subsessilibus glomeratis, calyce 5 lobo, lobis ovatis obtusis; petalis 5 glabris imbricatis obovatis vel ovatis; tubo glabro obconico crenulato; antheris exsertis; ovario ad basem puberulo.

A small tree about 20 ft. in height with a barrel about 6 in. in diameter. Young shoots, branchlets, underside of leaves, and parts of inflorescence ferruginous pubescent with stellate hairs, the indumentum very dense on the young shoots, young branchlets, midrib, and primary nerves of the under side of the leaves. Leaflets 4 or 5, the lateral ones on petiolules of about 1 line (2 mm.) or less, the terminal ones on petiolules of about 4 lines (8 mm.) or less, thin or almost membranous, elliptical or oblanceolate, acuminate, the terminal ones narrowed at the base, margins recurved, lateral nerves numerous and parallel, 2½-5 in. (6·4-12·8) cm. long, twice to three times as long as broad. Panicles in the upper axils, mostly shorter than the leaves, the ultimate branches consisting of very dense globular, ovoid, or oblong clusters of flowers. Flowers crowded, subsessile, globular, about 1 line (2 mm.) in diameter. Calyx beset on the outside with brown stellate hairs, divided for about two-thirds its length into 5 obtuse, ovate lobes about 1 mm. long. Petals 5, glabrous, strongly imbricate, obovate or ovate, about 1·5 mm. long. Staminal tube glabrous, obconical, slightly exceeding 1 mm. in length, crenulate at apex, anthers slightly exserted. Ovary (perhaps rudimentary) globular, minute, pubescent at base. (Text-figure 2.)

Hab.: Atherton Tableland, C. T. White (type); also received from the District Forest Officer, Atherton, without name of collector.

This species is distinguished from its nearest Australian ally, *Aglaia elæagnoidea* Benth., by the dense ferruginous hairs of its young shoots, branchlets, and under sides of leaves and by the dense globular, ovoid, or oblong clusters of flowers on the ultimate panicle branches.



Text-figure 2.

Aglaia ferruginea sp. nov. A, flowering shoot about half natural size. B, portion of under surface of leaf, × 5/2.

ORDER LEGUMINOSÆ.

Templetonia Hookeri Benth. Specimens of this shrub have been collected at Settlement Creek, North-west Queensland, by L. Brass, and constitute a definite locality record in the State for the species. The leaves in these specimens are occasionally 3-foliolate.

Psoralea pustulata F.v.M. The following are definite localities for this little-known species: Lower Settlement Creek, L. Brass; Georgina River, E. J. Whelan; Lawn Hill, F. Hann (all near Queensland-Northern Territory Border); Walsh River, Cape York Peninsula, T. Barclay Millar.

Tephrosia coriacea Benth. This Northern Territory plant, previously unrecorded for Queensland, has been collected on sandstone ridges at Settlement Creek, North-west Queensland, by L. Brass.

Atylosia cinerea F.v.M. This Northern Territory shrub, which was previously unrecorded for the State, has been collected at Branch Creek, North-west Queensland, and Settlement Creek, Queensland-Northern Territory Border, by L. Brass; and at Townsville, North Queensland, by J. W. Fawcett.

Rhynchosia acutifolia F.v.M. Definite Queensland localities for this species are—Gilbert River, F. v. Mueller; Tate River, R. C. Burton; near Railway Crossing, Tate River, C. T. White. R. C. Burton's specimens bear pods containing 2-3 seeds, a peculiarity already noted by Bentham in Mueller's specimens from the Gilbert River. Some specimens in the Queensland Herbarium simply marked "Hann's Expedition" also have pods which are mostly 3-seeded.

Dalbergia monosperma Dalz. This twining shrub, which is distributed in parts of India, China, Malaya, and Northern Australia, has been collected on the edge of Mangrove Swamps at Cairns by C. T. White, and was previously unrecorded for the State.

Acacia lycopodifolia A. Cunn. This Northern Territory shrub was collected at Settlement Creek, North Queensland, near border of Northern Territory, by L. Brass, and is a new record for the State. It was recorded by Bailey in the "Queensland Flora," ii., p. 483, as a Queensland species, and the locality Hammersley Range given. Hammersley Range, however, is in the north-west of Western Australia.

Acacia flexifolia A. Cunn. A New South Wales species not previously recorded for this State which has been collected at Catfish Creek, Inglewood District, by C. J. Smith.

Acacia myrtifolia Willd. has been collected in the following localities:—Logan River, Rev. B. Scortechini; Russell Island,

Moreton Bay, Miss E. N. Parker; summit of Glasshouse Mountains, F. M. Bailey; Beerwah (associated with *Acacia complanata* in Eucalyptus forest), C. T. White. In the "Queensland Flora," ii., p. 489, F. M. Bailey recorded *A. amœna* Wendl. from the Glasshouse Mountains. C. T. White recently collected a series of specimens of *A. myrtifolia* from that district, and on examination found them to be identical with F. M. Bailey's specimens referred to *A. amœna*. *A. amœna* should, therefore, be deleted from the list of Queensland Acacias. J. H. Maiden, in "Forest Flora of New South Wales," v., p. 185, had expressed his doubt as to this species occurring in Queensland.

Acacia translucens A. Cunn. A Northern Australian species, not previously definitely recorded for Queensland, which has been collected at Massacre Inlet, Gulf of Carpentaria, by L. Brass. J. H. Maiden, in his paper on the Tropical Acacias of Queensland, p. 24 (Proceedings of Royal Society of Queensland, vol. xxx.), excluded this species, as the only locality recorded in the "Queensland Flora" (p. 494) was "Islands of the Gulf of Carpentaria." The present record now definitely establishes the plant as a Queensland species.

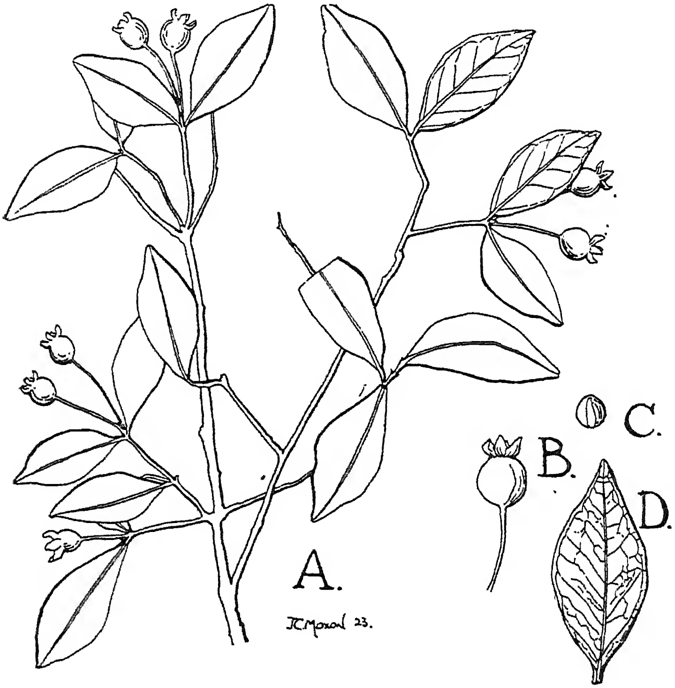
Acacia Muelleriana Maid. & Bak., Proc. Linn. Soc. N.S.W., viii. (2nd series), p. 515, pl. 25. A New South Wales species collected at Chinchilla by J. E. Young, and constituting a new record for the State. The Chinchilla specimens have slightly broader leaflets than those of the type, but resemble exactly specimens from Minore, N.S.W. (ex. Nat. Herb. Sydney). The plant is very different in appearance from any other Queensland species of Acacia.

ORDER MYRTACEÆ.

Eugenia macrohila sp. nov. Arbor parva vel frutex diffusis; foliis glabris, ellipticis vel oblanceolatis breviter petiolatis obtuse acuminatis vel raro obtusis subcoriaceis; floribus ignotis; fructibus solitaris pedicellatis globosis puniceis; seminibus solitariis.

A straggling shrub or a small tree with an irregular or leaning barrel attaining about 6 in. diameter. Leaves elliptical or oblanceolate, narrowed at the base into a very short petiole, obtusely acuminate or less frequently obtuse at the apex, rather thick in texture, margins slightly recurved, at least in dried specimens, lateral nerves oblique, generally

3 to 5 conspicuous on each side of the midrib, $1\frac{1}{4}$-$2\frac{1}{2}$ in. (3·2-6·4 cm.) long, 2 to 3 times as long as broad. No flowers available. Fruit solitary in the upper axils on slender pedicels attaining 8 lines or rarely reduced to 1 line in length, young fruit finely pubescent with minute appressed hairs, mature fruit attaining about $\frac{1}{2}$ in. (1·3 cm.) in diameter (when fresh), red, the pulp sweet and very pleasant to the taste. Persistent calyx-lobes 4, narrowly ovate or narrowly triangular, obtuse, 2-$2\frac{1}{2}$ lines



Text-figure 3.

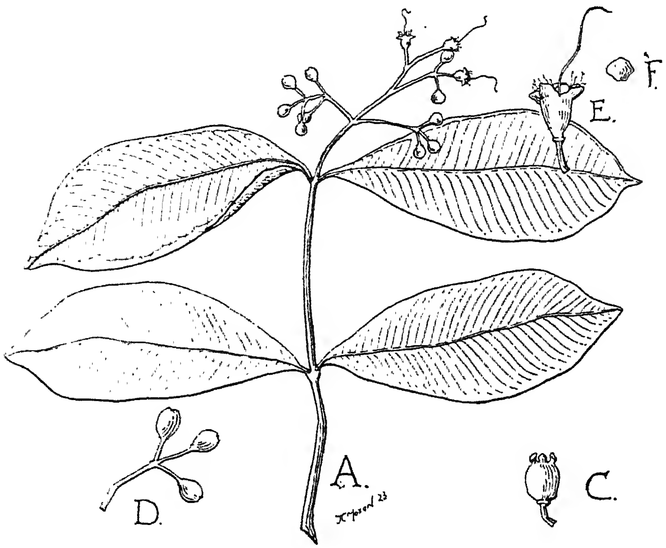
Eugenia macrohila sp. nov. A fruiting branchlet. B, mature fruit. C, seed. D, leaf showing veining. All half natural size.

(4-5 mm.) long. Endcarp thin, readily broken with the fingers. Seed solitary, globular or slightly ovoid, $\frac{1}{4}$-$\frac{1}{3}$ in. (6-8 mm.) in diameter ; hilum broad and nearly as long as the seed. (Text figure 3.)

Hab. : Màrmor, 26 miles south-east of Rockhampton, W. D. Francis, March, 1920.

This species is allied to *E. carissoides* F.v.M., from which it is distinguished by its narrow leaves, slender pedicels, and the elongated calyx-lobes crowning the fruit.

Eugenia Petriei sp. nov. Arbor, ramulis foliisque glabris; foliis tenuiter coriaceis obovatis apice acuminatis basi in petiolum satis longum cuneatim coarctatis, costis lateralibus utrinque ultra 30 cum costa intramarginali a margine ca. 2 mm. remota conjugentes; floribus mediocribus in cymam terminalem pauciflorum digestis; calycis tubo turbinato (4 mm. longo), lobis 4, hyalino marginatis; petalis 4, suborbicularibus, (ca. 2 mm. diam.) staminibus 4 mm. longis, stylo 1·1-1·3 cm. longo; bacco oblonga 1-sperma.



Text-figure 4.

Eugenia Petriei sp. nov. A, flowering shoot. C, fruit. D, flower bud. E, flower. F, petal. A and C about half natural size, D natural size, E and F $\times$ 2.

A medium-sized tree, glabrous in all parts. Leaves thin-coriaceous, obovate, mostly 4-4½ in. (10-11·3 cm.) long, and 1½-2 in. (3·8-5 cm.) broad; finely veined with numerous close parallel veins, the main lateral veins 1½-2 lines (3-4 mm.) apart with finer veinlets between them, the intramarginal vein mostly about 1 line (2 mm.) from the margin, veins and veinlets conspicuous on both faces in the dried leaf, apex abruptly acuminate or more or less tapering into an acuminate point, base gradually tapering into a petiole of 2-3 lines (4-6 mm.). Flowers white, not very numerous, borne in terminal trichotomous cymes usually shorter than the leaves. Cymes pedunculate

or sometimes sessile; peduncles, branches, and pedicels rather stout. Calyx turbinate, 2 lines (4 mm.) long, lobes 4, scarcely 1 line ($1\frac{1}{2}$ mm.) long, margin hyaline. Petals narrowed at the base into a very short claw, suborbicular, about 1 line (2 mm.) diameter. Stamens very numerous, 2 lines (4 mm.) long. Style slender, 5-6 lines (1·1-1·3 cm.) long. Fruit blue, oblong, about $\frac{1}{2}$-in. (1·3 cm.) long but not seen quite ripe, 1-seeded. (Text-figure 4.)

Hab.: Fraser Island, W. R. Petrie.

This tree in the past has been confused with *E. cyanocarpa* F.v.M., and when one of us (C. T. W.) was on Fraser Island in May 1921 Mr. Petrie drew his attention to it and *E. cyanocarpa*, which is also common there; the two trees are quite distinct in the field, *E. Petriei* seems to be more or less confined to the creek banks, the branches usually overhanging the water.

In botanical sequence this new species comes nearest to *E. cyanocarpa*, the distinctions being as follows:—

Leaves 2-4 in. long, $\frac{3}{4}$-$1\frac{1}{2}$ in. broad; stamens $\frac{1}{2}$ in. long or more; fruit globular—*E. cyanocarpa*.

Leaves mostly 4-$4\frac{1}{2}$ in. long, $1\frac{1}{2}$-2 in. broad, stamens 2 lines long, fruit oblong—*E. Petriei*.

Order UMBELLIFERÆ.

Siebera Billardieri Benth. var. **lanceolata.** All the Queensland specimens in the Queensland Herbarium represent the above variety. We have specimens from the following localities:—Macpherson Range, H. Tryon, C. T. White; Helidon, F. M. Bailey; Crow's Nest, Kenny and White; Cooroy, H. A. Longman; Fraser Island, F. C. Epps, J. E. Young.

Order COMPOSITÆ.

Olearia oliganthema F.v.M. This New South Wales shrub, which was previously unrecorded for Queensland, was collected on the Macpherson Range, Killarney district, by C. P. Saunders. The Queensland specimens differ from the type in possessing larger flowers and in the involucral bracts being densely silky pubescent. The description in the "Flora Australiensis" was drawn up from meagre material, and the plant evidently shows a much greater variation than there described.

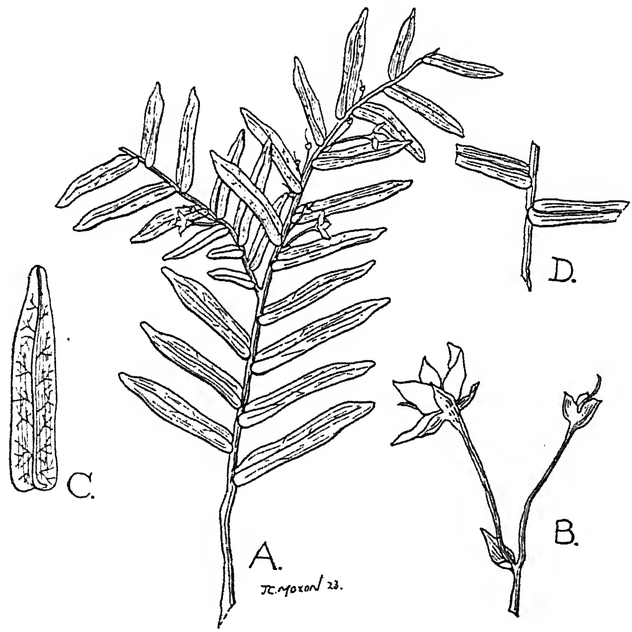
Order EPACRIDEÆ.

Epacris longiflora Cav. Collected on Mount Lindesay by W. Hill. J. E. Young and C. T. White also collected it there recently, and noticed that it was common on cliff faces. We

also have specimens from Springbrook, Macpherson Range, collected by Mr. J. Tait. It was omitted from the "Queensland Flora" although recorded from Mount Lindesay in the "Flora Australiensis." This mountain is on the border of New South Wales and Queensland, but almost wholly within the latter State. The species is common in the sandstone flora of New South Wales.

ORDER MYRSINACEÆ.

Ardisia bifaria sp. nov. Frutex erectus glabrus; foliis alternis distichis subsessilibus pellucido-punctatis, oblongo-lanceolatis basi auriculatis; floribus racemosis, racemis axillaribus 2-5 floris; pedicellis capillaribus; sepalis 4 lanceolatis petalis 4 ovatis acuminatis; staminibus 4; ovario ovoideo.



Text-figure 5.

Ardisia bifaria sp. nov. A, flowering shoot. B, flowers, × 3. C, leaf showing venation. D, shoot showing attachment of leaves. A, C, and D, about half natural size.

A shrub attaining 4 ft. in height, glabrous. Branches terete. Leaves alternate, dotted with pellucid glands, distichous, subsessile, oblong-lanceolate, tapering but obtuse at the apex, cordate at the base, appearing oblique on account

of the lower basal auricle often overlapping the upper surface of the branchlet, and the upper basal auricle overlapping the under surface of the branchlet, midrib immersed and a few *indistinct primary veins visible on upper surface of leaf, midrib* raised and primary veins slightly more evident on the under side ; measurement of leaf-blade, 1-2 in. (2·5-5 cm.) long, 4-6 times as long as broad. Flowers in short axillary racemes of 2-5 flowers, the rhachis about 1 line (2 mm.) long. Pedicels capillary, 3-4 lines (6-8 mm.) long, each subtended by a lanceolate, concave bract about ½-line (1 mm.) long. Calyx divided to the base into 4 lanceolate sepals about ½-line (1 mm.) long ; petals 4, very shortly united and overlapping at the base, ovate, acuminate, nearly 1½ line (3 mm.) long. Stamens 4, subsessile, lanceolate or narrowly traingular, subcordate, about 1 line (2 mm.) long ; slits of anther cells extending to the full length of the cells. Ovary ovoid, tapering into a fairly slender style. (Text-figure 5.)

Hab. : Bellenden-Ker, common in lowland forests, C. T. White (flowering specimens, type) : Glenallyn, Atherton Tableland, Gourka Pocket, Atherton Tableland, C. T. White.

ORDER SAPOTACEÆ.

Lucuma castanospermum (C. T. White) n. comb. This species was described and named from fruiting specimens by C. T. White as *Chrysophyllum castanospermum* in Bot. Bull. xxi., p. 12, Department of Agriculture and Stock, Brisbane. Examination of flowers, recently collected on the Atherton Tableland by G. Curry, shows that the species should be placed in *Lucuma*. Following is a description of the flowers, which were not available previously :—

Calyx-lobes 5, ovate, obtuse, imbricate, silky pubescent, about 3 lines (6 mm.) long. Corolla-tube shortly cylindrical or constricted about the middle, hirsute inside towards the base, about 5 lines (10 mm.) long ; lobes 5, their margins overlapping towards the base, broadly ovate, obtuse, about 1 line (2 mm.) long. Staminodia 5, obtuse, alternating with the corolla-lobes and about two-thirds their length. Stamens alternating with the staminodia and inserted lower in the corolla-tube ; filaments slender, under ½-line (1 mm.) long ; anthers ovate, almost 1 line (2 mm.) long.

The presence of the staminodia in the flower and the absence of albumen in the seed indicate that this species should be assigned to *Lucuma*.

Sideroxylon Brownlessianum F.v.M. Fragm. vii., p. 111; F. M. Bailey, "Queensland Flora," iii., p. 959. Fruit, which were previously unknown, have been collected at Gadgarra, Atherton Tableland, by A. L. Merrotsy and C. T. White. Following is a description of them:—Fruit oval, 1 in. long and ½-in. in diameter, 2-seeded. Seeds narrowly obovate, ¾-in. long; testa dark brown, glossy; hilum linear, about three-fourths the length of seed.

Order APOCYNACEÆ.

Alstonia longissima F.v.M., Papuan Plants, 1 (v.), p. 91 (1877). Specimens of this plant collected at Port Moresby, Papua, by C. T. White, show that the species is identical with A. *somersetensis*, Bail., "Queensland Agricultural Journal" i, pp. 229, 368 (1897). Bailey's specimens were collected at Somerset, Cape York Peninsula, by F. L. Jardine, and his name must lapse in favour of Mueller's earlier one. The species is figured on page 324 of Bailey's "Comprehensive Catalogue of Queensland Plants."

Order LAURACEÆ.

Cryptocarya foveolata* sp. nov. Arbor magna, ramulis juvenilibus pubescentibus; foliis alternis petiolatis ovatis vel ellipticis obtuse acuminatus subtriplinervis prominente foveolatis utrinque reticulatis; paniculis terminalibus vel axillaribus; floribus breviter pedicellatis, perianthii tubo obconico, lobis ovatis; bacca globosa.

A tree attaining a height of about 100 ft. and a barrel diameter of about 2 ft. Barrel not prominently flanged. Bark brown, fairly smooth; when cut, light brown, $\frac{7}{16}$-in. thick on a tree with a barrel diameter of 1 ft. 9 in. Sapwood white. Young shoots pubescent. Leaves alternate, on petioles 2-4 lines (4-8 mm.) long, ovate, lanceolate or elliptical, mostly shortly and obtusely acuminate, a pair of lateral nerves prominent towards the base giving the leaf a triplinerved appearance; the other lateral nerves are very few and distant, both surfaces reticulate. The most prominent features of the leaves are the one or two pairs of hollow glands (domatia)

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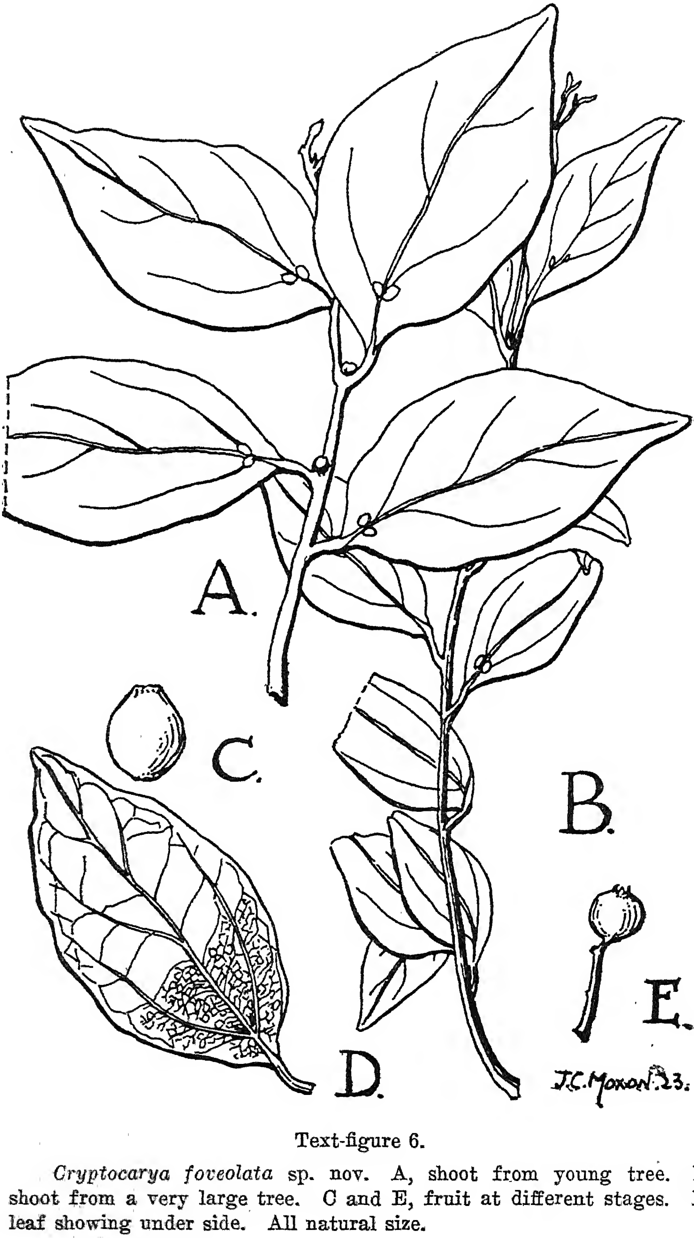
* Though this tree was originally named *C. cinnamomifolia* Benth. var. *parvifolia* by the late F. M. Bailey, the name *parvifolia* has already been applied specifically to a Philippine Island species of *Cryptocarya* by E. D. Merrill.



Text-figure 6.

Cryptocarya foveolata sp. nov. A, shoot from young tree. B, shoot from a very large tree. C and E, fruit at different stages. D, leaf showing under side. All natural size.

situated along the midrib at the axils of the principal lateral nerves forming protuberances on the upper surface and with orifices on the under side. Measurement of leaf-blade 1-2½ in. (2·5-6·5 cm.) long, 1½ to 3 times as long as broad. Panicles terminal and in the upper axils, very slender and raceme-like, generally shorter than the leaves. Flowers very shortly pedicellate. Perianth turbinate or campanulate, about 2 lines (4 mm.) long, the obconical tube about as long as the lobes, pubescent inside; lobes ovate, about 1 line (2 mm.) long. Stamens of the outer series nearly as long as the perianth segments; anthers ovate, obtuse; filaments broad, finely puberulent. Glands (6) at base of stamens, subsessile, ovoid or nearly globular, obtuse, puberulent at base, about ·5 mm. in diameter. Three inner stamens lanceolate, obtuse, about as long as the outer ones, filaments broad and flat, finely ciliate on the margins. Three staminodia alternating with the three inner stamens on short broad stipites, broadly ovate, acute, cordate and puberulent at base, about 1 mm. long. Ovary immersed in the calyx-tube, narrowly ovate, puberulent with a few minute appressed hairs; style cylindrical, glabrous, apparently articulate above the ovary. Fruit black, globular, about ½-in. (1·2 cm.) in diameter, crowned by the small circular scar of the perianth tube. *C. cinnamomifolia* Benth. var. Bail. Cat. Queens. Woods 1886 and subsequent editions No. 313A; *C. cinnamomifolia* Benth. var. *parvifolia* Bail. "Queensland Flora," pt iv., p. 1301 (1901). (Text-figure 6.)

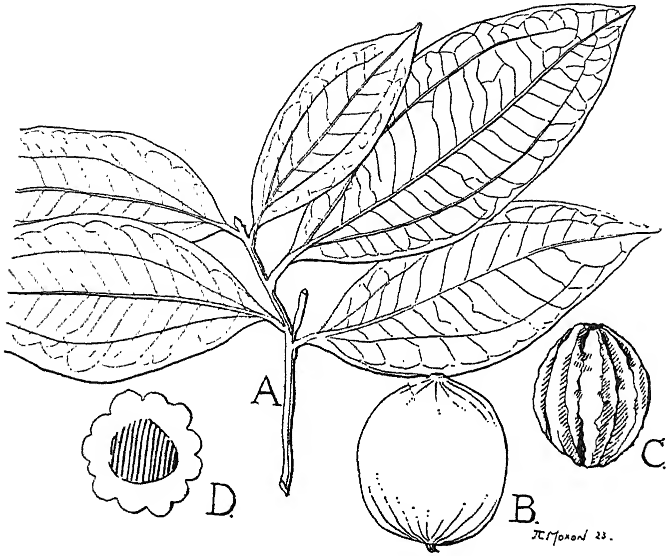
Hab.: Mount Mistake, F. M. Bailey; Roberts Plateau, Macpherson Range, C. T. White; Ranges eastward of Emu Vale, C. B. Saunders, W. D. Francis.

This tree is allied to *Cryptocarya cinnamomifolia* Benth., from which it is distinguished by its smaller leaves containing large domatia and lacking a glaucous under-surface, and by its globular not-depressed fruit.

Cryptocarya pleurosperma sp. nov. Arbor magna novellis sericeo pubescentibus; foliis petiolatis alternis ellipticis obtuse acuminatis prominente triplinerviis supra nitidis; floribus ignotis; fructibus ovoideo-globosis; seminibus rugoso-costatis, costis ca. 12.

A tall tree, young buds silky pubescent. Young branchlets angular towards the growing points. Petioles somewhat flattened in the upper part or the leaf laminæ shortly decurrent, 3-5 lines (6-10 mm.) long. Leaves alternate elliptical, shortly and obtusely acuminate, prominently triplinerved, transverse

veins visible but not prominent, upper surface smooth and glossy, under surface darker and duller, measurement of lamina $3\frac{1}{2}$-$5\frac{1}{2}$ in. (9-14 cm.) long, 1·5-2·5 times as long as broad. No flowers available. Fruit ovoid-globular, red, over $1\frac{1}{2}$ in.



Text-figure 7.

Cryptocarya pleurosperma sp. nov. A, leafy shoot. B, fruit. C, seed. D, seed in transverse section showing thick, ribbed putamen. All half natural size.

(3·8 cm.) long. Seed ovoid-globular, rugose and very prominently longitudinally ribbed, ribs generally 12 in number, putamen walls 2-4 lines (4-5 mm.) thick. (Text-figure 7.)

Hab.: Bellenden-Ker, C. T. White (type); Gadgarra, Atherton District, T. Fuller; Johnstone River, Rev. N. Michael.

In its triplinerved leaves and costate seeds this species resembles *C. australis* Benth., to which it is apparently closely allied. It is distinguished from *C. australis* by its more strongly costate and larger very rugose seeds which are twice the size, and its broader and larger leaves.

ORDER PROTEACEÆ.

Persoonia oxycoccoides Sieb. This species, previously known from Victoria and New South Wales, has been collected at Inglewood, west of Warwick, Southern Queensland, by C. J. Smith.

PLACOSPERMUM gen. nov.

Flores hermaphroditi. Perianthium cylindraceum regularis vel parum irregularis, superne recurvum (segmentis 4, demum solutis ?). Stamina 4, antheris linearibus quorum 3 imperfectis, filamentis infra medium perianthii insertis. Glandulæ hypogynæ 4, angustæ. Ovarium subsessile, angustum, ovulis numerosis uniseriatis. Folliculus coriaceo-lignosus, pluris-permus. Semina compressa, samaroidea, late alata. Arbor. Folia alterna, integra, coriacea, pennivenia. Flores racemosi, racemis ad apices ramorum paniculatis.

Flowers hermaphrodite. Perianth terete or cylindrical, recurved in the upper part ; segments 4, regular or nearly so. Anthers 4, but only one perfect in each flower, linear, with 2 linear parallel cells adnate to the connective ; filaments erect, linear or oblong, inserted below the middle of the perianth segments. Hypogynous scales 4, linear or setaceous, distinct. Ovary scarcely stipitate, narrow and terete ; ovules numerous ; style continuous with the ovary. Fruit a follicle with a thin, woody exocarp, 1-celled. Seeds numerous, in a single row, flat and broadly winged ; testa membranous ; cotyledons thin and flattened. A tall tree. Leaves alternate, often crowded towards the ends of branchlets, entire and penninerved. Flowers singly pedicellate in racemes arranged in panicles at the ends of branchlets ; pedicels subtended by bracts.

Derivation : From Greek *plax*, a flat body ; *sperma*, a seed ; alluding to the flattened seeds.

This genus evidently constitutes a new tribe of the sub-family Grevilleoideæ, as it cannot be included in any of the tribes described in Bentham and Hooker's " Genera Plantarum " or Engler and Prantl's " Naturlichen Pflanzenfamilien." The new tribe, for which we propose the name Placospermeæ, could be placed between Embothrieæ and Banksiæ as under :—

Sub-family Grevilleoideæ.—Flowers in pairs or single in the axils of the bracts. Ovary with 2 or numerous ovules. Fruit with 1 or numerous seeds.

Grevilleæ.—Ovary mostly with 2, rarely 4, ovules.

Embothriæ.—Ovary with 4 or more ovules in two series.

Placospermeæ.—Ovary with 15 or more ovules, in a single series. Seeds transversely arranged in the follicles.

Banksiæ.—Ovary with 2 collateral ovules.

Placospermum coriaceum sp. nov. Arbor glabra ; ramulis validis ; foliis petiolatis spathulatis vel oblanceolatis obtusis coriaceis, marginibus integris recurvulis ; paniculis terminalibus

foliis brevioribus; bracteis concavis, ovatis vel triangularibus; floribus pedicellatis, corolla superne recurva; staminibus corolla fere æquantibus; folliculis subglobosis obliquis, plurispermis, seminibus ca. 20 uniseriatis, compressissimis late alatis.

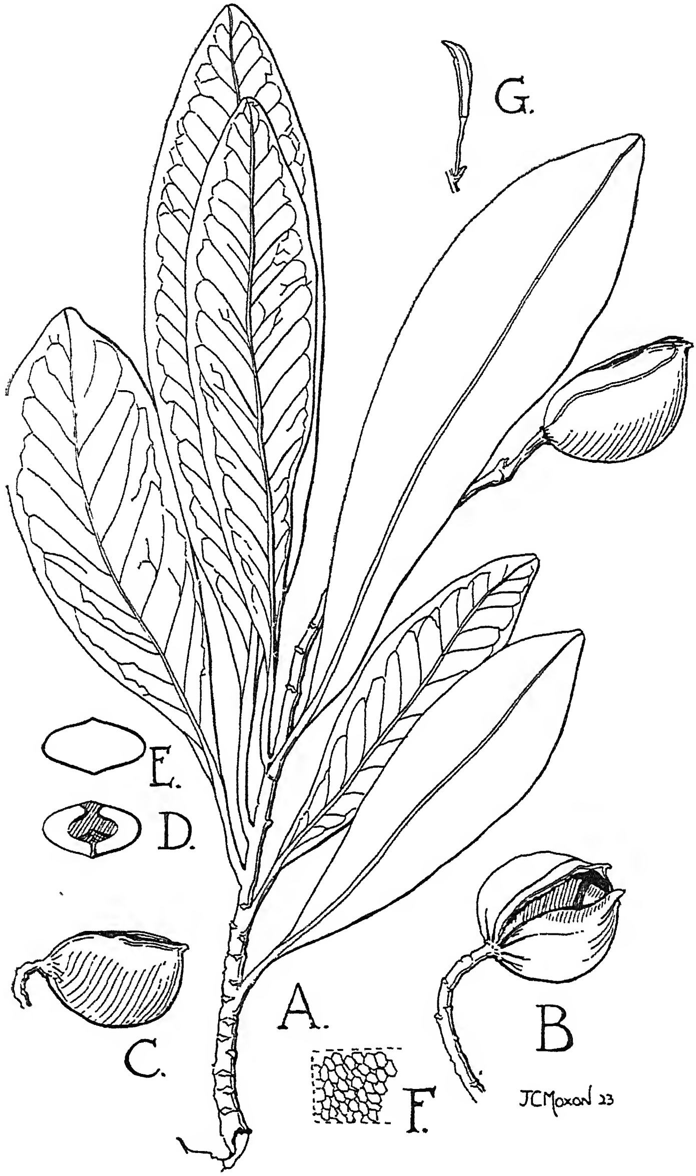
A tall tree, all parts glabrous. Branchlets thick, marked by the broad cicatrices of fallen leaves. Leaves spathulate or oblanceolate, obtuse, coriaceous, margins entire and minutely recurved, tapering into a petiole $\frac{1}{2}$-$\frac{3}{4}$ in. (1·3-1·9 cm.) long; midrib, lateral nerves and a few reticulate ones visible on both surfaces; measurement of leaf-blade 4-7 in. (10·7-17·8 cm.) long 3-5 times as long as broad. Panicles shorter than the leaves. Bracts subtending the pedicels concave, ovate or triangular, over 1 line (2 mm.) long. Pedicels about $\frac{1}{2}$-in. (1·3 cm.) long. Perianth about $\frac{1}{2}$-in. (1·3 cm.) long. Stamens nearly as long as the perianth segments, the filaments of the fertle ones about 1 line (2 mm.) long. Hypogynous scales about 2 lines (4 mm.) long. Ovary terete, about 4 lines (8 mm.) long including the continuous style. Follicles subglobose, oblique, about $1\frac{1}{2}$ in. (3·8 cm.) in diameter. Seeds about 20 in each follicle, arranged in a single row and filling the follicle, flat and strongly compressed, broader than long, $\frac{3}{4}$-$1\frac{1}{4}$ in. (1·9-3·2 cm.) broad including the broad wing. (Text-figure 8.)

Hab.: Mount Alexander, near Daintree, North Queensland, ex Queensland Herbarium, without collector's name (flowering specimens, type); Reserve 418 Danbulla, Atherton district, Forest Ranger D. Fraser (fruiting specimens).

To Mr. B. F. Kruger, Wood Technologist, Queensland Forest Service, we are indebted for the loan of a sample of the wood of the species. The sample is a cylindrical piece about $2\frac{1}{2}$ in. in diameter, either a section from the barrel of a young tree, or from a branch. Examined in cross-section with a lens it shows no "soft tissue" (wood parenchyma), a somewhat unusual feature for a Proteaceous wood but which is also a characteristic of the wood of *Embothrium Wickhami* F.v.M. The vessels ("pores") are numerous, isolated, or in groups of two or four. The rays are fine and number from about 28-36 to the cm. in tranverse section; in a tangential section they are seen to be from ·5-1 mm. in height. The wood is light brown in colour.

ORDER EUPHORBIACEÆ.

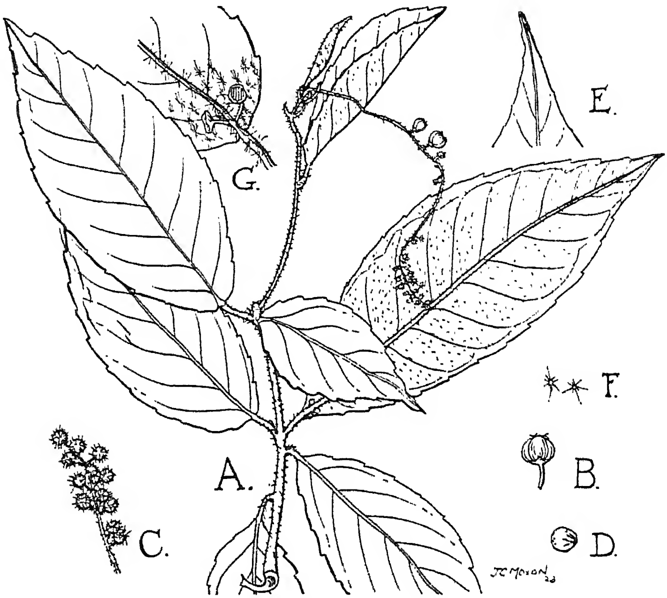
Croton densivestitum sp. nov. Arbor ramulis dense stellato-pubescentibus; foliis petiolatis, petiolis dense pubescentibus; foliis alternis raro suboppositis vel subverticillatis, ellipticis lanceolatis vel oblanceolatis acuminatis supra



Text-figure 8.

Placospermum coriaceum gen. et sp. nov. B and C, follicles. D and E, seeds. F, reticulate surface of wings of seeds. G, a single flower. All half natural size except F ($\times 5$), and G (natural size).

glabratis subtus pubescentibus biglandulosis ; stipulis setaceis vel capillaribus ; racemis terminalibus dense pubescentibus, bracteis setaceis ; floribus pedicellatis, calyce alte 5-lobato intus hirsutis ; capsulis dense stellato-pubescentibus, stigmatis bifidis ; seminibus subglobosis.



Text-figure 9.

Croton densivestitum sp. nov. A, flowering twig, about half natural size. B, fruit, about ⅝ natural size. C, terminal portion of raceme, × 3/2. D, seed, natural size. E, apex of leaf. F, stellate scales, × 10. G, base of leaf, under side, showing glands, × 4.

A shrub, the branchlets inflorescence and under sides of leaves densely pubescent with stellate hairs. Branchlets terete. Petioles densely pubescent, ¼-1 in. (·6-2·5 cm.) long. Leaves alternate, occasionally nearly opposite or whorled, elliptical, lanceolate or oblanceolate, shortly but not broadly rounded at the base, prominently acuminate, margins serrate or entire, upper surface nearly glabrous, midrib and primary lateral nerves visible on both surfaces, the reticulate ones obscure, glands situated on the under side of the leaf, one on each side of the base of the midrib where the basal lateral nerves join it, glabrous and obconical ; measurement of leaf blade 3½-5½ in. (9-14 cm.) long, twice to thrice as long as broad. Stipules

when present setaceous or almost capillary, 1-2 lines (2-4 mm.) long. Racemes terminal, 2-3 in. (5-7·7 cm.) long, males in the upper, females in the lower portion. Bracts subtending the pedicels, setaceous, about ½-line (1 mm.) long. Pedicels ½-1 line (1-2 mm.) long. Calyx hirsute inside, divided nearly to the base into 5 lanceolate lobes, about ¾-line (1·5 mm.) long. Petals (in male flowers) 5, lanceolate or oblong, obtuse, ciliate on the margins, ¾-line (1·5 mm.) long. Stamens 10-12, slightly shorter than the petals; anthers ovate. Capsule stellate pubescent, tridymous, 3-4 lines (6-8 mm.) broad; styles divided into 2 branches about 1 line (2 mm.) long. Seeds subglobose, pale brown, mottled or streaked with dark brown, about 2 lines (4 mm.) in diameter. (Text-figure 9.)

Hab.: Harvey's Creek, F. M. Bailey (Bellenden-Ker Expedition of 1889); (type); lowland rain forests, Bellenden-Ker, C. T. White, March 1922 (fruiting specimens).

Among the Queensland species this one is apparently allied to *C. arnhemica* Muell. Arg. var. *urenæfolius* Bail. (to which it was referred by Bailey in Report of Bellenden-Ker Expedition) and to *C. acronychioides* F.v.M. From the latter it is distinguished by its dense indumentum and long acuminate leaves, and from the former by its narrower almost non-reticulate leaves and smaller flowers and fruit.

ORDER CONIFERÆ (TAXACEÆ).

Podocarpus spinulosa R. Br. This New South Wales undershrub, which was not previously recorded for the State, has been collected and noticed to be very abundant by C. T White on Stradbroke Island, in the sandy forest land between Dunwich and Point Lookout. The specimens (collected in March and July) bore leaves only.

P. Ladei Bail. This species was described from specimens bearing leaves and immature fruit. A. L. Merrotsy has recently collected mature fruiting specimens from the same locality, Mt. Spurgeon, North Queensland, in which the type material was collected. He described the trees as not exceeding 3 ft. in barrel diameter, and collected the fruiting specimens in February 1923. The mature fruit are bluish black, ellipsoid, fleshy, 1½ in. (4 cm.) long, 1 in. (2.5 cm.) broad; seed 1-1⅙ in. (2·5-3 cm.) long, 8 lines (1·7 cm.) wide, the apex with a short, sharp, apiculate point. Bailey's description and illustration are in the "Queensland Agricultural Journal," vol. xv. (1905), p. 899 pl. 22.

ORDER GRAMINEÆ.

Panicum ctenanthum F.v.M. This grass, which was previously unrecorded for Queensland, has been collected at the Gilbert River, North Queensland, by C. T. White. The specimens differ from the type in having most commonly 3 instead of only 2 spikes to the head, the spikes are also longer —4 in. (10 cm.) long—but otherwise agree with the description of the type material.

P. majusculum F.v.M. ex Bentham Fl. Austr., vii., 482, 1878; Ewart and Davies, Flora North. Terr., 38, 1917. This grass, which was previously unrecorded for Queensland, has been collected at the Gilbert River, North Queensland, by C. T. White. The specimens differ from the original description quoted above in having the outer glume 5-7-nerved instead of 3-nerved. Examination of type specimens kindly lent by Mr. Laidlaw from the National Herbarium, Melbourne, showed the outer glume to be often more or less distinctly 5-nerved.

Notes on the Physiography of Eastern New Guinea and Surrounding Island Groups.

WITH SPECIAL REFERENCE TO THE VOLCANIC FEATURES OF THE RABAUL DISTRICT OF NEW BRITAIN.

By C. H. MASSEY.

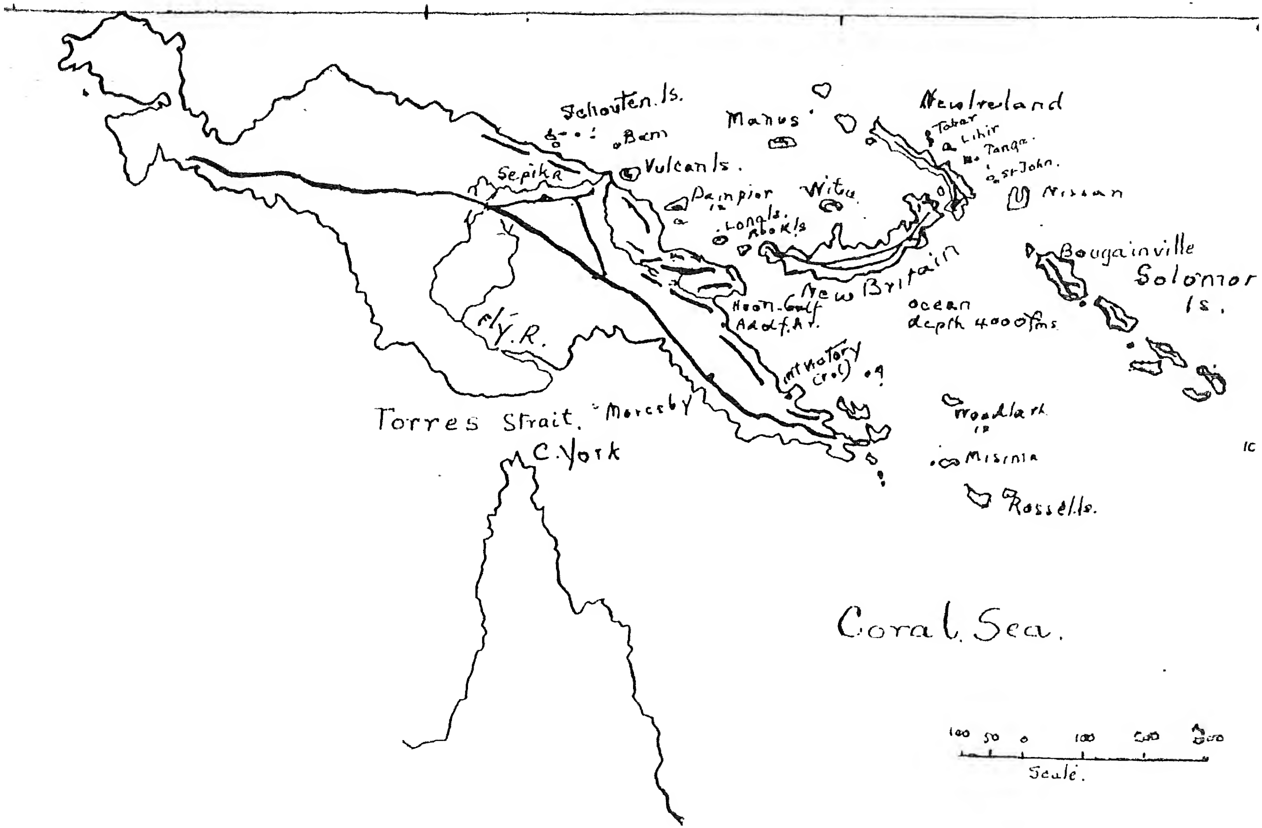
(Plate III, and Four Text Figures.)

(*Read before the Royal Society of Queensland, 24th July, 1923.*)

CONTENTS.

I.—INTRODUCTION.

I HAVE written this paper at the suggestion of those who think that the information given will be of interest and value to Australian Geology. By way of introduction, I must be allowed a few words of apology. I have had a certain amount of diffidence in preparing these notes, for several reasons. The whole area is so wide and so little known that there is not a great deal of reliable information available. The observations reported in this paper were made casually without any idea of future publication, and so lack the care and accuracy demanded in that case. A space of four years has elapsed since they were made, and though time allows maturer reflection, yet many facts are not so fresh to the mind as formerly. However, with these limitations, I propose to discuss the physiographic features of Eastern New Guinea and the adjacent island groups, with special reference to the volcanic features of the Rabaul



Schouten Is.
Bam
Vulcan Is.
Sepik R.
Manus
New Ireland
Tabar
Lihir
Tanga
St. John
Nissan
Dampier Is.
Witu
Long Is.
Rook Is.
New Britain
Huon Gulf
Adolf Hr.
Mt. Victory (Vol.)
Bougainville
Solomon Is.
ocean depth 4000 fms.
Fly R.
Torres Strait.
Moresby
C. York
Woodlark Is.
Misima
Rossel Is.
Coral Sea.
100 50 0 100 200 300
Scale.

area of New Britain. Most of the places referred to have been visited by the writer. For other information I am indebted to articles written by various officers of the garrison in the "Rabaul Record" (a publication issued monthly by the garrison at Rabaul for rather more than two years), and the excellent maps prepared by the Chief Surveyor, Rabaul, based on the Admiralty maps, corrected and brought up to date, from the latest information. I wish to thank Professor Richards, of the Queensland University, and his staff for much kindly help in the preparation of this paper. Other acknowledgments and references are made in the course of the paper.

II.—GENERAL PHYSIOGRAPHY.

The physiography of the area will be discussed in detail in later sections. It will only be necessary at the outset to draw attention to the more distinctive features. The general physiography of the area may be clearly seen in the sketch-map, text-fig. 1. The first thing that attracts notice is the parallelism in the trend-lines of Eastern New Guinea and New Ireland and the Solomons, and the apparent cross trend-line of the great peninsula and New Britain. In the arrangement of the mountain ranges of New Guinea something similar is seen. In the western part of the island the trend-line is west to east, the ranges extending nearly to the north-east coast. This trend seems to be continued in a parallel line in the great peninsula and New Britain. In the eastern part of New Guinea the trend-line is south-east. Parallel to the north-east coast-line is a series of volcanic islands, some active, rising directly out of the ocean upwards of 5,000 ft. They seem to be the peaks of a considerable range of mountains running parallel to the coast ranges and now submerged. This coast-line is generally bold throughout its length, and is flanked by series of coast ranges of varying altitudes up to 6,000 ft. The great peninsula is really a huge mountain massif built up of parallel ranges rising to a height of over 12,000 ft. in the Finisterre Range. The trend of these ranges is, as previously noted, west to east, crossing the trend of the coast-line and coast ranges. The general average height of the ranges of the peninsula seems to be from 5,000 to 8,000 ft. In New Britain, the average height, as far as is known, seems to be about 3,000 ft. with a few

peaks rising to 7,000 ft. New Britain, as far as is known, is entirely volcanic, and there are many craters both active and quiescent throughout its length. To the north of New Britain is a small group of islands known as the French Group. The main island is a great crater, partly submerged, known as Johann Albrecht. As observed inside, from the deck of a steamer, the crater must have a diameter of three miles. The walls are perfectly perpendicular to a height of about 600 ft., while the water in the crater is over 400 fathoms or 2,400 ft. deep. To the south of New Britain is one of the great deeps of the Pacific, known as the Planet Deep. Depths up to 4,000 fathoms have been recorded. Fringing the east coast of New Ireland is a series of volcanic islands roughly parallel to the coast-line. St. John Island is noted for its mud-springs and fumaroles, and contains at least one active geyser known as Balamusson. These islands rise out of deep water over 1,000 fathoms. The Rabaul volcanic system is situated at the extreme eastern end of the island of New Britain, surrounding the harbour known variously as Blanche Bay, Simpsonhaven, or Rabaul Harbour.

III.—HISTORY AND DEVELOPMENT OF THE RABAUL VOLCANIC SYSTEM.

The original crater of the Rabaul volcanic system is undoubtedly the depression known as Simpsonhaven. The definite walls surrounding the harbour, though now much weathered, composed of vast beds of yellow ash, pumice, and scoria, and the general shape, indicate this fact (text-fig. 2). Even in its original condition it must have been of considerable extent. At present the depression has a length of five miles and a breadth of two. The other craters are marginal to Simpsonhaven. The oldest seems to be Mount Mother, 2,500 ft. high, whose tall, steeply sloping sides indicate a typical tuff-cone (Plate III, fig. 1). This crater is quite extinct. Two further marginal craters were formed later, one at the foot of Mount Mother and the other on the South Daughter. These two craters appear much alike and no apparent distinction as to age is observable. They are both plugged, but contain active fumaroles. When Dampier visited Blanche Bay in 1699 he observed an active volcano on the north side of the bay. This probably refers to one of these craters. An eruption is reported to

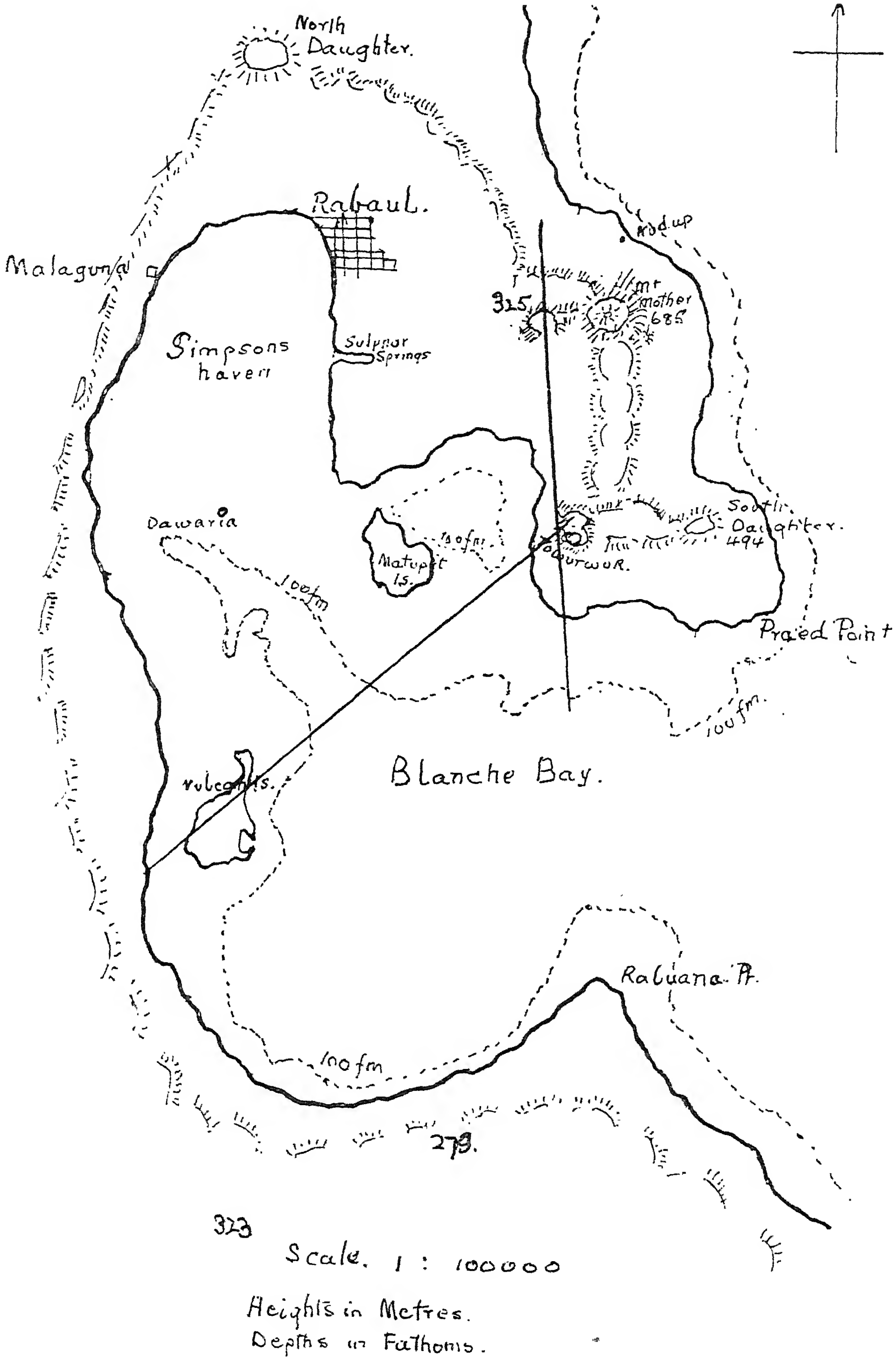


FIG. 2.—Sketch-map of Rabaul Harbour showing the situation of the craters, the shore-line topography, and the probable direction of the local rift-lines.

have occurred in a submarine crater, now known as Vulcan Island, on the western side of the harbour, somewhere about the year 1838. The latest crater is a cinder-cone formed on the margin of the South Daughter Crater. This was apparently formed and was violently active in the eruption of 1878. A full account of the eruption is given by the veteran Methodist missionary, Dr. Brown, in his "Reminiscences." The following facts may be noted:—The eruption was preceded by very violent earthquakes accompanied by tidal waves which destroyed a large part of the shore-line. Clouds of steam arose from the water in a line from Matupit Island to Vulcan Island (text-fig. 2). When the submarine crater at Vulcan Island broke out, the steam-clouds across the harbour cleared. Finally the crater on the South Daughter (Cinder Cone) burst out with terrific force, throwing up material to a great height and forming a column of smoke upwards of 4,000 ft. high. These explosive eruptions continued for some weeks. There was no discharge of lava, but great blocks of pumice and rock (consolidated ash) with yellow and black ash were continuously thrown out. St. George's Channel was a floating field of large blocks of pumice, and it is said no salt water was visible. The whole coast-line adjacent to the area was burnt out, and the waters of Blanche Bay and Simpsonhaven were at scalding heat throughout. All submarine life was destroyed.

The successive eruptions of this system have built up vast beds of ash which dominate the local topography for a radius of many miles. There is no sign anywhere, as far as the writer could see, in a radius of twenty miles, of the original topography.

Since 1878 there have been no further eruptions of this system, though many severe earthquakes have occurred.

IV.—PRESENT CONDITIONS.

The present conditions in the Rabaul district, as observed by the writer about four years ago, will be described under the following heads:—

(i) Craters;
(ii) Fumaroles;
(iii) Submarine activity;
(iv) Ashbeds;
(v) Seismic features.

(I) THE CRATERS.—Four of the craters will be described—(*a*) The South Daughter Crater, (*b*) the Cinder Cone, (*c*) Matupit Island and Harbour, (*d*) Vulcan Island.

(*a*) The older crater on the South Daughter (Plate III, fig. 2), known by the natives as Towurwur, is very similar to that at the foot of Mount Mother, and the following description will apply equally well to both:—The crater is breached on the harbour side by means of which there is an easy entry. The walls, which are steep, are built up of successive layers of yellow ash, pumice, and scoria, and in places covered with black cinder-ash from the cinder-cone. Around the margin of the floor may be seen masses of agglomerate, composed of blocks of hardened tuff and ash. The floor is covered with a smooth carpet of soft sulphur and ash mud. It is very hollow in sound and is probably not very thick. Both the floor and surrounding agglomerate are very hot. Numerous fumaroles are present around the margin.

(*b*) *The Cinder Cone* (Plate III, fig. 3).—This crater is the latest in the system. It has the steep, evenly formed slope of tuff-cones and is built up mainly of black cinder-ash. The crater itself is shallow and is filled up with ash and stones. In the centre is a small pit, probably the site of the last stages of the 1878 eruption. There are numerous active fumaroles around the walls of the crater.

(*c*) *Matupit Island and Harbour* (*see* Fig. 2 and Plate III).—Below the craters previously described, on the western side and forming part of the harbour, is Matupit Haven and Island. The coaling station which was to form part of the German Pacific Naval Base is situated on the island in a well-protected position. There are many interesting features to be observed here. The island itself is built up mainly of ash, ash-mud, and sand. At its northern end, the island was joined to the mainland by a causeway until the 1916 earthquake, when it subsided considerably. The water enclosed by the island is very deep and the shore-line abrupt and steep. The island slopes away very gently to the south and becomes ultimately merely a large sandbank, slowly being built up by the action of currents and tides and effects of S.E. monsoons. Along its eastern side, at the foot of the South Daughter craters, the water of the harbour is very hot and in places

gives off steam. All the evidence points to the fact that Matupithaven is a submarine crater, but it is impossible to observe its relation to the other craters except that it appears to be associated with the rift system.

(*d*) *Vulcan Island* (Fig. 2).—This is another submarine crater and it was active in the earlier stages of the 1878 eruption. At that time vast quantities of pumice and mud were thrown up, building the low island now known as Vulcan Island. On the edge is a small lagoon which is apparently part of the crater proper. The water is very hot, as is the adjacent mud.

All these craters are explosive in type and there is no sign anywhere of lava-flows or dykes, except one very small outcrop of dioritic rock at the base of Mount Mother. There is only a very small exposure, and it is impossible to give any opinion as to its nature.

(II) FUMAROLES.—Along the western margin of the South Daughter craters and in the Cinder Cone, around the shores of Matupithaven and at Vulcan Island, there are numerous fumaroles. They are continuously active. Some build up small sulphur cones and pipes, some are merely holes. The steam comes out in puffs at regular intervals. The steam is probably composed of water vapour and H_2S and SO_2, as clusters of delicate crystals of yellow sulphur are deposited around the vents. The sulphur fumes arise in such a quantity that, when the S.E. winds blow, the atmosphere is distinctly disagreeable in Rabaul over two miles away, and even strong enough to discolour silverware.

On closer examination, these vents are seen to follow two fairly definite lines—one in a north-and-south direction extending from the Cinder Cone to the old crater at the foot of Mt. Mother, and the other, commencing in Towurwur, can be traced along a small gully in a south-west direction to the water's edge, and is in a direct line with Vulcan Island and passing through Matupithaven. This latter is in fact the old line along which steam arose immediately preceding the 1878 eruption. Where these two lines intersect, there is quite a cluster of fumaroles and the rocks are very hot. Between the town of Rabaul and Matupithaven, on a plantation formerly owned by the Hamburg Südsee Aktien Gesellschaft, there is a series of hot sulphur springs.

(III) SUBMARINE ACTIVITY.—In many places in the vicinity of the craters, the water of the harbour is very hot. The temperature of the water rises and falls rhythmically. This seems to indicate the presence of submarine fumaroles.

Submarine eruptions of considerable intensity and in deep ocean water have been reported by the naval authorities off the south coast of New Britain.

(IV) ASH-BEDS.—As mentioned previously, the whole of the Rabaul area is built up of ash-beds extending for a considerable distance south and west. Good sections may be seen in the deep and narrow ravines near Bita Paka, about fifteen miles south-west of Rabaul. Sections may also be seen in the road cuttings on the Namanula Road at Rabaul. The different eruptions and stages of eruptions can be clearly marked at Bita Paka in the varying features of the ash. Numerous beds of yellow and brown ash and pumice are interspersed by beds of black scoria. Occasionally, large lumps of consolidated ash, similar to the agglomerate at the craters, are found embedded in the ash. The observed thickness is at least about 400 ft. It is impossible to state the total depth, as the base level of the streams is still in ash. The writer regrets that circumstances did not permit the making of a permanent record of the Bita Paka section. Judging by the presence of quantities of pumice and yellow ash, the original lava would seem to belong to the acid group.

(V) SEISMIC FEATURES.—The present activity of the area is further evidenced by continual tremors and occasional shocks of considerable violence. There has never been any accurate record kept, and needless to state there were no recording instruments. The area is not altogether suitable for recording instruments, on account of the soft nature of the ground. The facts recorded in this section are those observed by the writer and others who have been compelled to share many strange experiences of seismic energy.

Distinction must be made between the different classes of shock—

(1) The violent shocks of some amplitude affecting wide areas;

(2) The less intense shocks and tremors of medium amplitude affecting only local areas;

(3) Continuous tremors and microtremors, most of which are not felt.

(1) In the first class must be placed violent earthquakes such as shook the district in January, 1916. It was felt all over New Ireland and recorded in Sydney. A house was thrown over as far away as Toma to the west. It was accompanied by a tidal wave of considerable dimensions. A steamer of about 2,000 tons, lying at the wharf at Rabaul, was at one moment above the sheds and shortly afterwards was bumped on the bottom of the harbour. The wharf itself, which was specially built to withstand earthquakes, was buckled up as if it had been crushed. The intensity and amplitude were so great that coconut palms were swayed to the ground and troops camped on Matupit Island became sea-sick. The narrow causeway which had until then joined Matupit Island to the mainland and formed a roadway sank several feet, cutting off communication except by boat. The stores in Rabaul suffered considerably. All their goods were thrown into confused heaps on the floor. Many of those who did not escape out of the bungalows quickly had exciting experiences with heavy articles of furniture which were thrown in all directions.

Some wider tectonic origin must be sought for this class of shock. It is perhaps to be found in the readjusting and settling movements which must be frequently taking place in this somewhat unstable area.

(2) The second class of shock consists of quakes of medium amplitude and less intensity than the former, and only affecting the vicinity of the craters. Some of these are sufficiently energetic to cause people to leave the bungalows or, if happening at night, to throw them out of bed.

One of the more intense of these shocks occurred on Tuesday, 22nd May, 1917. It was felt at Kokopo, about twelve miles away, but not in the Duke of York Islands or New Ireland. It was preceded for some days by tremors and swarms of tremors with growing frequency and intensity. Immediately preceding the shock the movements ceased, at least visibly, for about thirty-six hours. This space of quietness was followed, about 9 a.m. on Tuesday, 22nd, by three violent shocks lasting upwards of a minute each. Each shock was preceded by loud rumblings, coming from the direction of the crater, becoming louder as the

shock approached. To those standing in the open, the ground seemed to roll in definite waves, which seemed to be travelling from the south-east—that is, from the direction of the craters. The bungalows rocked violently and threatened to fall from their foundations. Trees shook violently and posts of different kinds moved visibly. Considerable damage was done to glassware and furniture.

As far as could be judged without instruments, the shocks seemed to be travelling from the direction of the South Daughter craters. Fortunately, the intensity was not great though the amplitude seemed to be considerable. As no information is available as to the behaviour of the craters and fumaroles, and the interior condition being unknown, it is quite impossible to correlate this class of shock with any definite crateral condition, though all the evidence points to the craters as the seat of origin.

(3) Quite distinct from the former classes of shock are the frequent tremors and microtremors, most of which are not felt. The area seems to be in a state of continuous movement. The influence of these tremors, even when not felt, may be observed in any of the wells in the town of Rabaul. The water is in a continuously rippled condition.

V.—CONCLUSIONS.

It is proposed to discuss the evidence outlined in the previous sections under two heads—(i) the volcanic system, (ii) the general physiography of the area.

(I) The Volcanic System.—The ultimate origin of the Rabaul volcanic system is probably to be found in the great stress movements, to be described later, which folded and faulted the whole marginal area of the old continental mass that included Australia, New Guinea, and surrounding islands—Solomons, Hebrides, Fiji, Tonga, Kermadec, and New Zealand, and probably the East Indies. The volcanic systems of New Guinea and New Britain undoubtedly lie along zones of fracture caused by the earth movements. In this section, however, only the purely local conditions of the Rabaul volcanic system will be considered.

The following subjects will be dealt with:—

(1) The unstable conditions of the area;
(2) Local rift system;

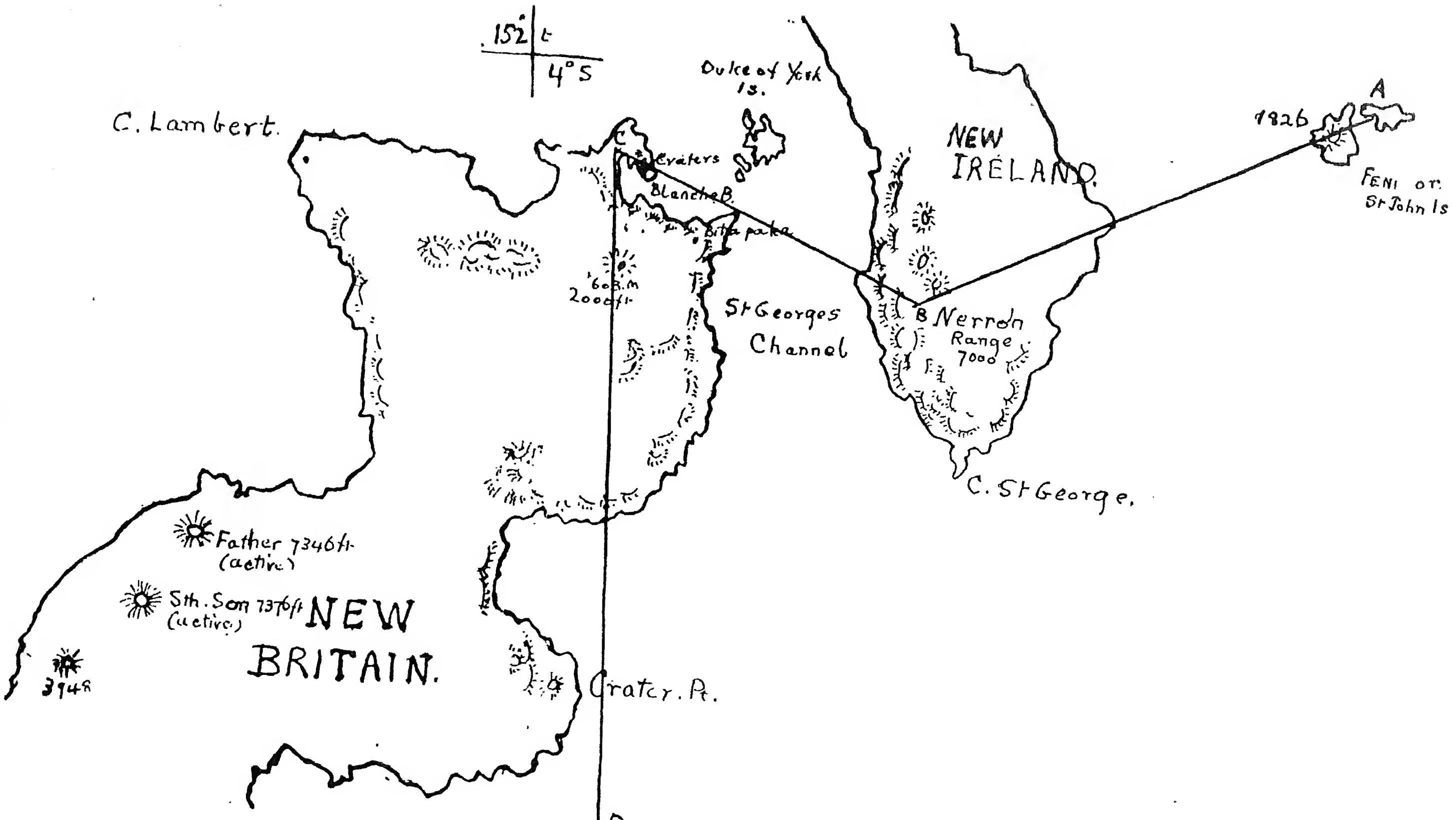


FIG. 3.—Sketch-map showing the relation of Eastern New Britain and Southern New Ireland.

(3) Condition of the craters;
(4) Causes of activity;
(5) Age and future activity.

(1) *Unstable Conditions of the Rabaul Area.*—The craters are situated on a very narrow peninsula, with the deep waters of St. George's Channel and Blanche Bay on either side. The slope is steep. The eastern slope of Mt. Mother drops from a height of about 2,500 ft. directly into St. George's Channel at its base. The other craters are similarly situated. A section line, commencing at Anir Island, drawn west and south through New Ireland, Mt. Mother, and South New Britain, gives a succession of high land and deep water (figs. 3 and 4). Operating in conjunction with these unstable topographic features are the periodic very high tides and the strains and stresses due to lunisolar earth warping.

In addition to these local conditions of instability, attention may also be drawn to the association of the high mountain mass of New Guinea with the great ocean deep situated between that island and New Ireland.

(2) *Local Rift System.*—As might be expected, there is evidence of a definite local rift system.. The fumaroles, as described in a previous section, have a definite linear arrangement in two directions, north-and-south and north-east–and–south-west (fig. 2). At the point of intersection the activity is considerable. This assumption is supported by the fact that in the earlier stages of the last eruption great clouds of steam arose along the east-west rift-line across the deep water of the harbour. All the craters of the South Daughter group are arranged about the rift system, as well as Mt. Mother, Matupit, and Vulcan Islands (fig. 2). Should further eruptions take place, it seems likely that a new crater will be formed at the intersection of the rift-lines. There, as previously stated, quite a number of fumaroles occur in close conjunction, forming a natural outlet for any further explosive activity.

(3) *Condition of the Craters.*—It is unfortunate that the craters are plugged, for it is impossible to observe their internal condition. Certain facts may, however, be deduced. The floor of the old South Daughter Crater rings very hollow and may be comparatively thin, covering a deep and

definite vent. It is quite certain that there is a deep-seated nucleus of great heat. The floor itself is hot, and immediately under the surface of the mud too hot to touch. The surrounding fumaroles, the very hot rocks, and the fact that well-waters around Rabaul, two miles away, are inconveniently hot below 20 ft., all provide evidence of a centre of great heat. There is no direct evidence at the present time of a lava column of any kind.

The yellow ash, scoria, and pumice of the 1878 eruption prove the presence of lava during that period. However, the continuous tremors and swarms, and the occasional greater tremors (coming from the direction of the craters), indicate the presence of stress movements there. If the observations made at the Halemaumau Seismometric Observatory, Mt. Kilauea, Hawaii,[1] provide any analogy, it is possible to assume the presence at least of a deep-seated lava nucleus. At Halemaumau these tremors and swarms have been definitely associated with recorded movements of the lava column. It is, however, possible that the tremors may be caused by other conditions present in the crateral area.

(4) *Causes of Activity.*—All the evidence seems to indicate that the causes of continued activity are to be found in the combination of tensional stresses and strains and the rift system. The action of the strains and stresses on the rift system result in the maintenance of the heat of the central nucleus, mainly by pressure release. This heat is further developed by thermo-chemical reactions.

Strains and stresses are set up by (*a*) the fact that the whole area is unstable and seems to be in a continual state of readjustment, (*b*) periodic high tides, and (*c*) luni-solar earth warping. All these factors operating in a rifted area will of necessity combine to set up crustal movements with accompanying earth tremors and shocks, and pressure release in the central heated nucleus. This seems to be the explanation of the present activity of the Rabaul volcanic system. The occasional outbursts of explosive energy may be due either to (*a*) the confinement of outflowing heat and

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[1] T. Jaggar: Seismometric Investigation of the Hawaiian Lava Column, 1920; Bulletin of the Seismological Society of America, vol. 10, No. 4.

gases, (*b*) sudden crustal warping of considerable extent, (*c*) the admission of large quantities of sea-water to the highly heated nucleus, or (*d*) a combination of one or more of these conditions. Normally, the fumaroles act as safety valves in allowing release of the gases up to a certain point.

Considering the explosive nature of the eruptions of this system, it is probable that the rift system has played an important part in the later phases of activity, especially as the waters of the harbour are so closely associated with it. It seems probable, judging from the description, that in the 1878 eruption the east-west rift-line opened as the result of crustal movements, allowing the admission of vast quantities of sea-water to the intensely heated area below; the sudden pressure release, rock fusion, gas expansion in the subterranean passages, oxidation, and other thermo-chemical mechanism providing the forces necessary to bring about a severe and continuous eruption. This is further borne out by the fact that the lava was thrown out entirely in the form of pumice and dust.[2]

It is also quite possible that this process is continuous in a small way, for it is practically certain that water percolates slowly into the heated interior. In addition to the waters of the harbour, there is the large catchment of water resulting from an annual rainfall of upwards of 100 inches. It is, then, quite probable that steam pressure and even the explosion of combinations of water vapour and other gases may be causes of some of the shocks, especially those accompanied by explosive rumblings.

(5) *Age and Future Activity.*—Modern investigation in volcanic areas has added very considerably to our knowledge of their history and formation. It is now generally considered "that explosive activity is an old-age feature of volcanism."[3] The same applies to yellow ash and cinder-cones which are associated with explosive activity. All the evidence goes to show that the craters of the Rabaul area represent the expiring stages of the activity of the system. The craters are more or less in a solfataric condition. There is now no evidence of anything but explosive action. The

[2] *See* Prof. J. W. Judd: "Krakatoa," 1884.

[3] *Cf.* Jaggar, *loc. cit.*, in a full discussion of the principles of volcanism.

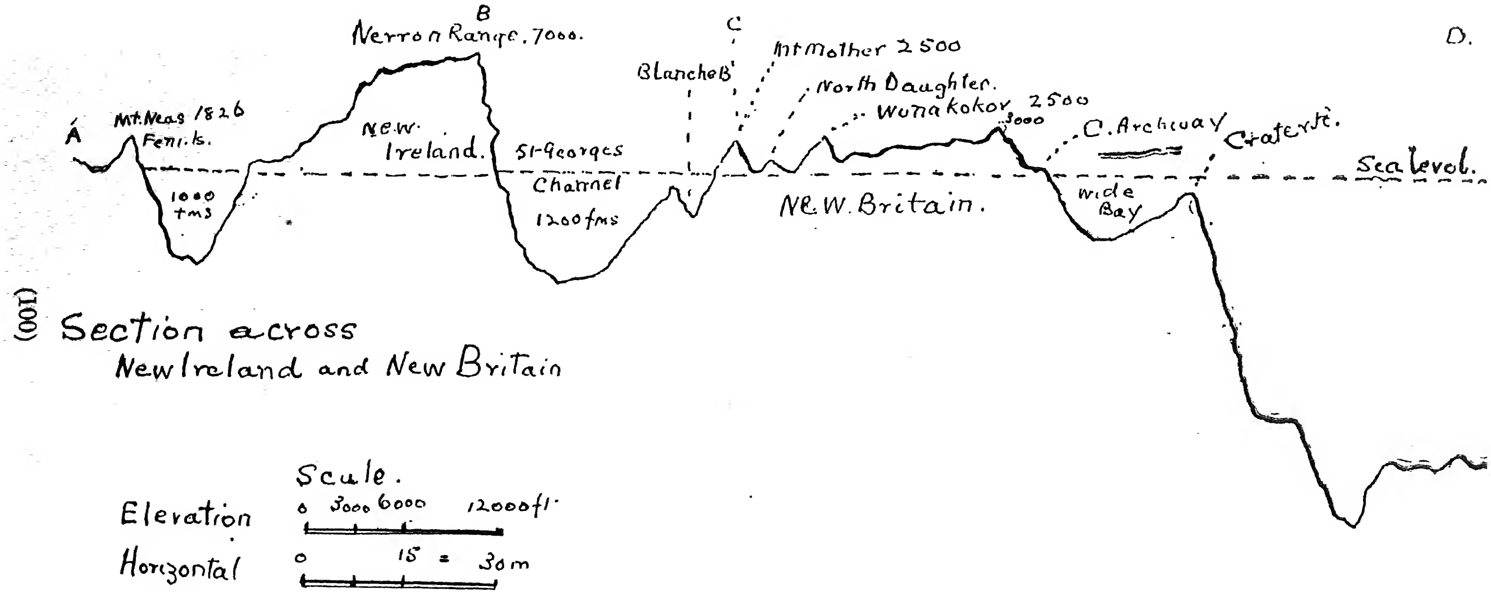

Fig. 4.—Sketch-section across New Ireland and New Britain.

whole district is built up of vast beds of yellow ash and pumice, sprinkled with scoria. The latest crater is a cinder-cone. Although the activity of this system seems to be expiring, yet the conditions described in the preceding subsections indicate the presence of forces sufficient not merely to cause a continuance of quiet activity but a sudden renewal of an intense explosive character.

(II) PHYSIOGRAPHY.—The following subjects will be dealt with under this subsection:—

(1) General physiography—
  (*a*) The trend-lines of New Guinea;
  (*b*) New Britain an area of subsidence;
  (*c*) New Ireland an area of uplift:

(2) Relation to the general topography of South-western Pacific:

(3) Relation to the earth movements:

(4) Relation to Australia.

(1) *New Guinea, New Britain, and New Ireland.*—In discussing the physiography of this area, it must be kept in mind that we are considering the marginal portion of the ancient continental area which originally included Australia, New Guinea, and surrounding islands—Solomons, New Hebrides, Fiji, New Caledonia, Tonga, Kermadec, New Zealand, and very possibly the East Indies.[4] From its relation to the Pacific Ocean and the continental mass, the area has been subjected to great stress movements.

The dominant trend-lines of this portion of the South-western Pacific are generally north-west to south-east. A difficulty is, however, presented by the general west-to-east trend of the great peninsula of New Guinea and the island of New Britain. Professor David, in the "Federal Handbook," describes New Britain as a probable virgation of the west-to-east trend of Western New Guinea. Professor Suess, in "Face of the Earth," vol. iv, considers the direction of the volcanic range in New Britain to be a difficulty in his theory of the Australian arcs. The writer ventures to suggest a theory, based on many personal observations, that will account for the present topography of the area.

[4] *See* paper by E. C. Abendanon: Jour. of Geol., vol. 27, 1919.

(*a*) *Trend-lines of New Guinea.*—An examination of the map (fig. 1) reveals some striking features. The mountain ranges of New Guinea seem to be arranged in two definite series grouped around a central massif which combines the trend-lines of both. One series has a definite west-to-east trend and the other a definite north-west–to–south-east trend. The former would include the main divide commencing at the western end of the island and extending eastward to the central group and continued almost to the north-east coast. An extension of this range, or at least parallel to it, are the mountains of the Finisterre group in the great peninsula and the volcanic range of New Britain. The general direction of the Sepik River lends support to the natural grouping of the mountains. The second series would include the main divide extending from the central group south-eastward to East Cape and continued in the Louisiade Islands. Parallel to this series are the north-east coast ranges extending from Dutch New Guinea to East Cape and the long group of volcanic islands fringing that coast-line. This arrangement of the mountains suggests two distinct trend-lines instead of one long arcuate ridge. The triangular arrangement of the central massive group is strongly suggestive of accommodation to two distinct movements.

(*b*) *New Britain a Subsidence Area.*—The volcanic islands fringing the north-east coast of New Guinea are undoubtedly the peaks of a considerable range of mountains now submerged. The general elevation of New Britain is much lower than that of either of the adjacent peninsula of New Guinea or of Southern New Ireland. The great crater of Johann Ahlbrecht, in the French group, is partially submerged, and has a depth of 2,400 ft. below the level of the ocean. The old Simpsonhaven crater at Rabaul is also partially submerged, and cannot represent its original elevation. Again, it is not probable that the present ash-beds represent its whole history. The earlier records have disappeared, presumably, beneath the ocean. Immediately to the south of New Britain is the Planet Deep. Soundings have indicated a widespread depth of upwards of 3,000 fathoms, with sinks of 4,000 fathoms deep and over. All this evidence and the general appearance of the land strongly suggested to the writer that New Britain is part

of an area of subsidence. Professor David, "Federal Handbook," page 321, mentions "a sheer cliff of quartz schist" facing the north-east at an elevation of 8,000 ft. on Mt. Suckling in South-east New Guinea. This indication of downthrow on the western side of the area strongly supports this suggestion.

(c) *New Ireland an Area of Uplift.*—Somewhere in the southern part of New Ireland there is a core of older rocks of a continental nature.[5] The exact locality is unknown, as the rock specimens were apparently picked up in the stream-beds. But, as far as I am aware and from many inquiries made, New Ireland seems to be mainly coralline in formation. At the northern end, a few miles south of Kawieng, the rock outcrops are recent coral formation. Those who have crossed the range between Namatanai and the west coast, in the centre of the island, report a similar structure at considerable elevation. The northern extremity of the island is low in elevation, and the land gradually rises in a southerly direction. At the southern end there is a huge piled-up mountain mass upwards of 7,000 ft., much higher than the rest of the island. Here the mountains fall steeply into the sea and have the appearance of a fault escarpment. The island groups off the east coast probably indicate a faulting and downthrow on the eastern side of the island similar to that reported by Mawson[6] in New Hebrides, subsequent elevation being aided by volcanic action. To the writer the evidence all points to the fact that New Ireland is an uplifted area. The extreme elevation of the southern end is probably due to the fact that it was, previous to these movements, a land area.

(2) *Relation to the Topography of the South-western Pacific.*—It may reasonably be asked, how does this theory fit in with the prevailing topography of the South-western Pacific?

For detailed discussions of the different parts of this area the reader is referred to the following works:—Mawson, "The Geology of New Hebrides," Proc. Linn. Soc. N.S.W., 1905; Woolnough, "Geology of Fiji," Proc. Linn. Soc. N.S.W., 1907; Professor Marshall, "Proceedings of

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[6] Proc. Roy. Soc. N.S.W., 1882, vol. 16, pp. 47-51; Proc. Linn. Soc. N.S.W., 1905, p. 400.

Australian Association for the Advancement of Science," 1911, and the same author's "Geology of New Zealand"; Guppy, "The Solomon Islands," 1887; Suess, "The Face of the Earth," vol. iv; Dana, "Manual of Geology," 4th ed., 1895, p. 37; Prof. David, "Federal Handbook," pp. 316-325.

From a study of these works, certain facts emerge—(*a*) The linear arrangement of the island groups in a general north-west–to–south-east direction; (*b*) the prevailing north-west--and–south-east strike of folds where noted; (*c*) the almost universal uplift of Tertiary limestones and coral reefs. These facts show that there is tectonic relationship between these groups. Mawson states that the South-west Pacific island groups are lined along great fold-chains concentric on the Australian foreland. The trend-lines of these island groups are practically continuous with those of Eastern New Guinea and New Ireland. The following ridges may be noted:—(*a*) New Ireland, Solomons, and New Hebrides; (*b*) Eastern New Guinea, Louisiades, New Caledonia, Norfolk Island, and the Auckland Peninsula of New Zealand; (*c*) another definite ridge having the same general trend-line west of the second ridge between New Zealand and Norfolk Island and the Thompson Deep. The Fiji group represents either a curve to the east in the direction of the first ridge or a parallel ridge. New Caledonia probably occupies a smaller ridge parallel to (*b*).

This grouping agrees with Professor Dana's arrangement of his Australian Chain, and seems, in view of all the facts, to be the natural one. Prof. Suess, "Face of the Earth," vol. iv, p. 301, makes the two branches of his first Australian arc link in Norfolk Island. This arrangement ignores the Gazelle Basin, an ocean deep, upwards of 3,000 fathoms.

Again, the contour of the ocean floor shows a succession of great ocean deeps extending from the Aldrich Deep to north-east of New Zealand, through the Gazelle Basin, between New Caledonia and the New Hebrides, and the Planet Deep between New Guinea and the Solomons to the coast of New Britain. These deeps have roughly the same direction as the trend of the land areas, and are suggestive of a long, somewhat irregular, trough in which New Britain is situated, lying between the two ridges first described.

These facts show that the theory seems to fit in quite naturally with what is known of the topography of the area.

(3) *Relation to the Earth Movements.*—From what is known of the geology of the South-western Pacific and the further observations of this paper, it would appear that there have been three dominant series of earth movements in this area since Palæozoic time—

(*a*) Resulting in the Tonga, Kermadec, and New Zealand ridge having a north–north-east trend.

(*b*) Resulting in the Himalayan–Burmese–East-Indian trend-line, having in the East Indies and New Guinea a west-to-east direction and including New Britain.

(*c*) A series of movements coming from the north-east creating the strong north-west–to–south-east trend-lines of the South-western Pacific.

The ancient continental area, whatever its exact extent may have been, seems to have existed more or less in this area until some time towards the close of the Jurassic Period. It was then that the first of these series of movements took place, uplifting the marginal area and forming the Tonga–Kermadec–New-Zealand ridge. These movements must have depressed much of the surrounding land, enlarging and deepening the great depression known as the Thompson Deep. All the vast series of Jurassic, Triassic, and older rocks of New Zealand have been folded and elevated. Many minor movements of uplift and subsidence have taken place since, but the direction of the axis of the land has remained the same.[7]

Early in the Tertiary Age, the second series of movements commenced, extending into late Pliocene times.[8] These were associated with the formation of the Burmese–East-Indian trend-line and building up the west-to-east ridges in New Guinea and New Britain. These movements were undoubtedly accompanied by strong volcanic activity, and the original craters of the Rabaul system seem to be at least as old as this period.

Following closely on the second series of movements in the late Pliocene or early Pleistocene time, the third

[7] Marshall: "Geology of New Zealand."

[8] Professor David: "Federal Handbook," p. 287.

series of movements took place. It resulted in the definite ridges and troughs between Australia and Fiji, forming the strong north-west–to–south-east trend-lines. This series of movements fractured the older west-to-east trend-line along the north-east coast of New Guinea. The volcanic islands of that coast and New Britain were folded or faulted downwards and the great ocean deeps created. The old schistose peniplain of Eastern New Guinea, New Ireland, and other groups of the area were elevated to a differential extent. Since that time there have been minor movements of adjustment complementary to the uplift when *e.g.* Torres Strait rift valley was formed, and perhaps the fault scarp mentioned by Professor David as occurring on Mt. Suckling.

With reference to these movements, it is of interest to note that the trend-lines of the first and third of these series movements meet in the north island of New Zealand, represented by the Tonga–Kermadec–New-Zealand ridge and the Eastern-New-Guinea–New-Caledonia–Norfolk-Island – and–Auckland-Peninsula ridge. The centre of the volcanic activity of New Zealand is found where these two lines meet. Active and extinct craters can be traced in both directions. Professor Bonney ("Volcanoes," 1902, p. 260) states that the "north island (of New Zealand) is probably situated at the junction of two zones of weakness." New Zealand geologists record a great outbreak of volcanic activity extending from the Miocene through the Pliocene period.

(4) *Relation to Australia.*—The relation of these movements to the general uplift of Eastern Australia in late Tertiary times is not altogether clear. The following facts are interesting and instructive:—

The coast-line of North-eastern Australia in its general trend is apparently related to the third series of movements. Dr. Walkom, in his paper on the Mesozoic of Eastern Australia, records a N. 30 W. trend in the folds of the rocks of that period. He merely states that they are post Lower Cretaceous. The dominant faults of North-eastern Australia have a north and north-western trend, this faulting being accompanied by the foundering of portion of the east coast. The great outbreak of alkaline eruptions in Australia is generally considered to be of Pliocene age. The

evidence for the late date of the uplift of Eastern Australia is summed up by Professor David in the "Federal Handbook," pp. 252, 287. Mention is here made only of the obviously recent age of the canyons of the rivers of Eastern Australia.

It is very probable then that, as far as Eastern Australia is concerned, the warping of the great peniplain was part of the third series of movements.

I have ventured to suggest this theory as a possible explanation of the direction of the volcanic range of New Britain, and also as the result of personal observations made in Eastern New Guinea, New Britain, New Ireland, and the Northern Solomons. It is based almost entirely on physiographic evidence, and awaits confirmation or otherwise until a more detailed examination of the area is available.

VI.—DESCRIPTION OF PLATE III.

Figure 1.—A photograph of Mount Mother, 2,500 ft. high, rising above the remnants of the wall of the old Simpsonhaven Crater. It shows the steeply sloping sides of a typical tuff-cone.

Figure 2.—A photograph taken on the side of the Cinder Cone looking west, showing the old South Daughter Crater and its floor. In the middle distance may be noticed the northerly portion of Matupit Island and the isolated rock in the harbour known as Dawaria. The background is the western shore of the harbour, and shows the more or less even skyline of the old wall of Simpsonhaven Crater. On the side of the Cinder Cone, ash and lapilli, thrown up in the last eruption, may be seen.

Figure 3.—A photograph of the interior of the crater of the Cinder Cone, showing the materials of which it is built and the small pit in the centre. Over the edge of the crater, on the extreme right, may be seen the southern shore of Matupit Island.

Fig. 1.

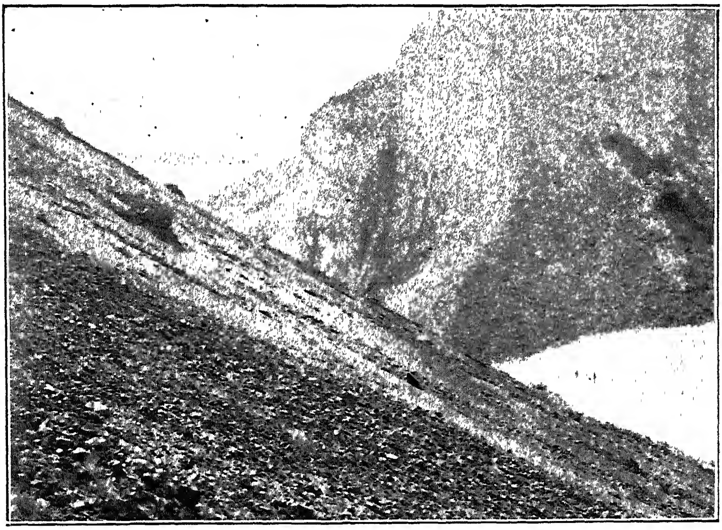

Fig. 2.

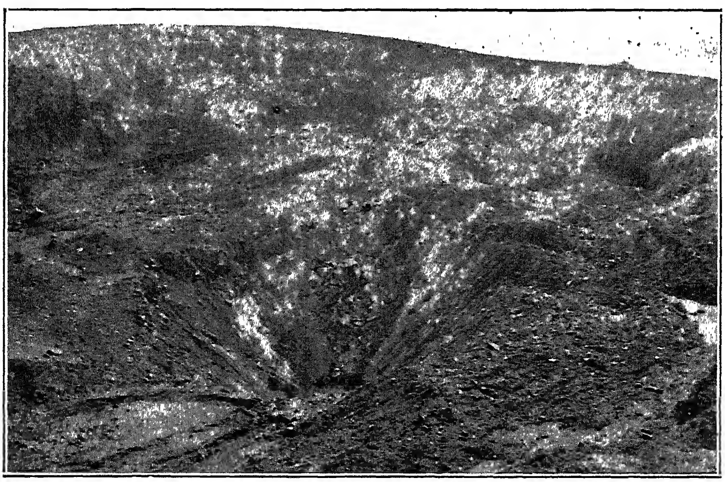

Fig. 3.

Face page 108.

Permo-Carboniferous Volcanic Activity in Southern Queensland.

By Professor H. C. Richards, D.Sc., and W. H. Bryan, M.Sc., University of Queensland.

(Plate IV., and Text-figure 1.)

(Read before the Royal Society of Queensland, 24th September, 1923.)

(I.) INTRODUCTION.

During the course of field investigations carried out in recent years in the Silverwood-Lucky Valley area, some 10 miles to the south of Warwick, the authors were particularly impressed by the fine development of great series of lavas and tuffs met with in several parts of the district. Both the flows and the associated pyroclastic rocks are for the most part of an acid nature, but more basic volcanics are represented in the upper part of the series. On account of their effective resistance to weathering, the rocks under discussion are generally the dominating topographical forms in their immediate locality, and in some cases cause important divides.

The thickness of this great series of volcanics as exposed in the Eight Mile Fault Block is about 5,000 feet, but there is reason to believe that a large strike fault has caused duplication, so that a minimum thickness is in the neighbourhood of 2,500 feet. However, since the uppermost beds in this faulted area may not represent the last phases of vulcanicity, and as the volcanic material found in the

different fault blocks may not represent identical horizons, the total thickness of Permo-Carboniferous volcanics which have been extruded in the area may far exceed this amount.

The interest in this series was in part petrological, for many very beautiful examples of spheroidal and fluidal structures have been observed, but this intrinsic interest was surpassed when sufficient evidence had been accumulated to definitely indicate that the series was Permo-Carboniferous in age, and interbedded with fossiliferous Upper Marine strata.

The only other area where volcanics of this age are at all extensively developed in Australia, so far as the authors are aware, is in the Southern Coalfield area of New South Wales, and there the rocks are in marked contrast chemically with those under discussion. In the Drake area two series of lavas and tuffs have been described, both of which resemble in some respects those of the Silverwood-Lucky Valley area, but they are regarded by Andrews[1] as of Lower Marine, Permo-Carboniferous age.

(II.) THE SILVERWOOD-LUCKY VALLEY AREA.

Faulted down into the Silverwood Series of Andesitic Tuffs and Radiolarian Cherts of Devonian age, there are four blocks of different sizes, composed of Permo-Carboniferous material. Three of these are largely made up of volcanic rocks, while the fourth contains much tuffaceous matter, but little in the way of lava flows.

These blocks have been termed by the authors—

(i.) Eight Mile Block,
(ii.) Tunnel Block.
(iii.) Stanthorpe Road Block.
(iv.) Condamine Block.

The first two have had a pronounced effect upon the topography, as there is a marked parallelism between the strike of the rhyolite and dacite flows and the backbone of the ridges. Apart from the areas of hornfels around the margins of the intruding granite of late Permian times, these areas of Permo-Carboniferous lava flows mark the

[1] Report on Drake . . . N.S.W. Geol. Sur. Min. Res., No. 12., p. 9.

highest country. In the third block there is little in the way of lava flows, and there is no apparent effect upon the topography of the area, but in the fourth block the highest ground in the neighbourhood is marked by the interbedded rhyolite tuffs, and a very close relationship exists between the direction of the ridge and the strike of these tuffs.

(*i.*) *Eight Mile Block.*—This is an area of eight square miles, and is situated around and about the Eight Mile Range and the Rhyolite Range. The former range is so-called locally on account of its distance south of Warwick, while the latter, which runs N.N.W. from the Eight Mile Range, has been named by the authors on account of its petrological nature.

This block is composed of mudstones, sandstones, grits, and conglomerates containing fossils belonging to the Upper Marine stage, and interbedded with them are mudstones containing Glossopteris and Noeggerathiopsis. Conformably bedded above the fossiliferous sediments there are rhyolites, dacites, andesites, and basalts, and with these are rhyolitic and dacitic tuffs.

The rhyolites and dacites much preponderate over the andesites and basalts, while the sequence appears to have been from earliest to latest—rhyolite, dacite, andesite, and basalt. Interbedded with the rhyolite and dacite flows are large thicknesses of the tuffs.

Approximately two-thirds of this block appears to be composed either of lava flows or of tuffs, so that we have between 5 and 6 square miles covered by their outcrops.

(*ii.*) *Tunnel Block.*—This is a wedge-shaped block about 2 miles long by ½ mile wide, and is situated north of the railway tunnel about 1½ miles north-west of Cherry Gully Railway Station. The length, which is a little west of a north-south line, corresponds to the strike of the flows and tuffs. In its petrological character it much resembles the material in the Rhyolite Range further to the north, and it is composed almost entirely of rhyolite flows, some of which are porphyritic and others spherulitic and fluidal. Conformably bedded below the lava flows are mudstones containing *Productus brachythærus* and shallow water sediments closely comparable with those below the volcanic material of the Eight Mile Block, so that the age of this

material is very similar to that of the Eight Mile Block. The relationship between the strike of the flows and the direction of the ridge is very marked.

(*iii.*) *Stanthorpe Road Block.*—This is about 10 miles south of Warwick, and is composed of sediments belonging to the Lower Marine stage, the Lower Freshwater stage, and the Upper Marine stage. Interbedded with the last-named are one or two thin flows of rhyolite and a certain amount of tuffaceous material, but the importance of this occurrence, compared with the other blocks, is very small.

(*iv.*) *Condamine Block.*—This is situated about the Condamine River, 14 miles south-east of Warwick. Interbedded with the Upper Marine sediments is a series of rhyolite tuffs about 700 feet thick. Conformably bedded beneath the tuffs are tuffaceous mudstones containing abundant remains of *Trachypora Wilkinsoni*, &c., while above them are rhyolite grits containing *Martiniopsis subradiata, Trachypora Wilkinsoni, Productus brachythærus*, &c., so that there is little doubt as to the Upper Marine age of the tuffs.

General Nature of the Activity, &c.

Rhyolitic and dacitic effusions much preponderate, and with the exception of the Eight Mile Block there is little other than Rhyolite flows and tuffs. The fossils associated with the effusions are those characteristic of either the Upper Marine Stage or the Upper Freshwater Stage, but all are of the shallow water type.

Probably the lowest portions of the Eight Mile Block and the Tunnel Block material were laid down in a shallow sea, but the great bulk of the volcanic material appears to have been extruded under terrestial conditions. At the Condamine and Stanthorpe Road Blocks, however, all the tuffaceous material appears to have been laid down as shallow marine deposits.

The rhyolitic and dacitic effusions were interrupted by extensive explosive phases, and in the Eight Mile Block the Eight Mile Range is composed almost entirely of dacite flows and tuffs, while the Rhyolite Range is made up of rhyolite flows and tuffs.

Much of the rhyolite was very viscous, as it frequently shows well-developed fluxion structure.

The concluding effusions appear to have been dense andesites and basalts, and although there is not any tuffaceous material associated with these latter flows, there is, at one point on Rhyolite Range, a very coarse rhyolite breccia immediately underlying the andesitic material, indicating quite local and intense volcanic explosion previous to the andesitic effusions at that point.

The volcanic activity was characterised by—

(*a*) An increasing basicity as it progressed;

(*b*) The amount extruded being inversely proportional to the basicity.

(III.) PETROLOGY.

As indicated above there are in the thickness of at least 2,500 feet of volcanic material, both flows and tuffs. The flows range from acid to basic in character, and the former much predominate. Many of the fine-grained rhyolite tuffs are difficult to distinguish from flows, and recourse to microslides is necessary. Except in the Eight Mile Range, which is largely dacitic, almost the whole of the volcanic material is rhyolitic in character.

Rhyolites.

These are variable, but both lithoidal and fluidal types are common, while spherulitic structure is frequently developed in a striking manner in the hand specimen. The colour varies through pink, lavender, and grey, to white—the last especially on the weathered surfaces. Porphyritic crystals of quartz, orthoclase, and plagioclase occur, and frequently spherulites have developed around the felspar crystals.

The descriptions of the three following rhyolites may be regarded as representative of the various flows in the several blocks under consideration:—

Rhyolite from Eight Mile Range, near the Summit, Portion 2161, Parish of Wildash. This is a deep lavender-coloured rhyolite containing numerous small phenocrysts of sanidine and very occasional small rounded crystals of quartz in a very fine groundmass. Fluxion structure is shown well in the hand specimen. The specific gravity is 2·628. Under the microscope its holocrystalline character is apparent, and one sees idiomorphic phenocrysts of

orthoclase varying from 0·5 to 0·75 mm. in length set in a groundmass of a trachytic nature and composed of quartz, felspar, and small dark rods and granules of a mineral which may be dark-brown hornblende. The rock has been analysed and the results are shown on Table I. (*Micro. 359.*)[2]

Rhyolite from The Hump, Rhyolite Range, Portion 8v, Parish of Wildash. This rock, which is typical of much of the material of Rhyolite Range and of the Tunnel Block areas, is pale-pink on the fresh surface and white on the weathered surface. It shows fluxion structure very freely, and here and there through the very fine groundmass there is an occasional crystal of felspar. Under the microscope a few crystals of cloudy orthoclase are seen, set in crypto-crystalline groundmass through which there are frequent streaks of secondary silica corresponding to the lines of flurion. Density 2·561. (*Micro. 452.*)

Spherulitic Rhyolite from The Hump, Rhyolite Range. In the hand specimen there are isolated rounded spherulites of cloudy felspathic material set in a greenish-grey groundmass, giving much evidence of secondary silicification. The spherulites average approximately 5 mm. in diameter, and occur frequently enough to be separated from one another by a few millimetres only. Under the microscope the groundmass shows as a cryptocrystalline mass through which there is much secondary silica. The spherulites appear to be masses of kaolin stained brown by limonite. Density 2·526. (*Micro. 453.*)

Dacites.

The dacites are difficult to distinguish from some of the rhyolites, but have a more melanocratic appearance. They are markedly porphyritic and are of two types, one showing quartz and felspar phenocrysts, and the other felspar phenocrysts only.

The descriptions of the two following rocks will serve to illustrate very well the main characteristics of the dacites.

Dacite from Portion 1663, Parish of Wildash, Eight Mile Creek. In the hand specimen it is a dark-grey colour with abundant clear rounded crystals of quartz and stout crystals of a pink plagioclase. Under the microscope the

[2] These numbers refer to the petrological collections in Dept. of Geology, Univ. of Qld.

phenocrysts give much evidence of having been attacked by the matrix, as the edges are rounded and sometimes the crystals are embayed. The felspar phenocrysts sometimes form composite masses up to 4 mm. in diameter, but their average length is about 2 mm. The felspar phenocrysts give an extinction such as to indicate medium andesine (Ab_{65}—An_{35}). The groundmass is hemicrystalline and hyalopilitic, with crystals of quartz and felspar, together with small rod-like crystals of a ferromagnesian mineral which was perhaps originally augite but is now chlorite. Density 2·650. (*Micro. 370.*)

Dacite from the centre of Portion 2274, Parish of Wildash, Eight Mile Range. In the field this rock was difficult to distinguish from the first rhyolite described. It is deep lavender in colour, with small phenocrysts of pink felspar. Under the microscope the phenocrysts are seen to occur up to 1 mm. in length and to show multiple twinning. It is difficult to determine them, but they appear to be of the andesine-oligoclase type. The groundmass is pilotaxitic and contains abundant small allotriomorphic crystals of quartz and felspar set in amongst the cryptocrystalline material. Density 2·609. (*Micro. 455.*)

ANDESITES.

The andesites vary from light-grey to purple in colour and from markedly porphyritic to non-porphyritic types.

The three following rocks will serve to illustrate the important characteristics of the andesites:—

Andesite from the top of Rhyolite Range, due east of Bald Mountain. In the hand specimen this is a purple-brown in colour with abundant phenocrysts of plagioclase of various sizes but frequently equidimensional. Under the microscope the phenocrysts of plagioclase show marked twinning and are determined as medium andesine (Ab_{65}—An_{35}), from the extinction angle. Some of the felspars show definite zoning. The groundmass is hyalopilitic and fluxion structure is very evident. Little other than minute crystallites of plagioclase and glassy material may be seen in the base. Abundant granules of ilmenite, partly weathered into leucoxene, occur through the field. Density 2·691. (*Micro. 447.*)

Andesite from Portion 1663, Parish of Wildash, Eight Mile Creek. This is a light-grey slightly porphyritic type, which has a specific gravity of 2·747. Under the microscope small phenocrysts of plagioclase up to 1·25 mm. long are seen set in a hyalopilitic groundmass. Fluxion structure is well developed, and in the groundmass there are granules of augite up to 0·25 mm. in diameter. These granules also occur as inclusions in the felspar phenocrysts. There is much alteration, calcite and epidote being abundant. This rock has been analysed, and the results may be seen in Table I. (*Micro. 361.*)

Andesite from the east of Portion 1179, Parish of Wildash, Eight Mile Range. In the hand specimen the rock appears light-grey in colour and has abundant phenocrysts of milky-white plagioclase and dark augite set in a grey base. Under the microscope the phenocrysts show much zoning in some cases, and those which are not zoned give an extinction angle indicating basic andesine. The plagioclase phenocrysts range up to 3 mm. in length and the augite crystals up to 1 mm. long. The latter are usually fresh and often show twinning. The phenocrysts of plagioclase are more frequently zoned and perhaps more basic than in some of the other andesites. This andesite, however, is representative of a great thickness of material. The groundmass is rather of the pilotaxitic type and distributed through it are abundant granules of magnetite. Density 2·639. (*Micro. 394.*)

Basalts.

These are not at all abundant, but they are always very dense, fine-grained, and rather platy in character. The following one, which has been analysed and whose analysis is given in Table I, may be taken as typical:—

Basalt from centre of portion 2161, Parish of Wildash, Eight Mile Range. In the hand specimen it is very compact and heavy, having a density of 2·847. It is very fine grained and weathers to a deep-brownish soil. Under the microscope one notes its hemicrystalline nature with a hyalopilitic groundmass showing marked fluxion structure. Throughout the field there are occasional lath-shaped crystals of medium andesine (Ab_{60}—An_{40}) and stout crystals of augite. These are set in a mass of crystallites of plagioclase, augite, and magnetite. (*Micro. 364.*)

Breccias and Tuffs.

These vary in size from quite coarse breccias, with fragments the size of walnuts down to very fine tuffs. Not uncommonly one finds interbedded layers of material of widely different coarseness. Some of the breccias have been much silicified and consist of angular fragments of cryptocrystalline rhyolitic material cemented together by secondary quartz and chalcedony. The breccias all appear to be rhyolitic in character, which is, perhaps what one would expect, while the tuffs are rhyolitic, dacitic, and andesitic in nature.

Chemical Characters.

The accompanying five analyses and their norms serve to indicate the general chemical characters of the volcanic rocks. The rhyolite and the basalt are both in a fresh condition, but the rhyolite tuff and the two andesites show by the carbon dioxide and water contents that they have undergone a considerable amount of alteration.

The lavas are all very much richer in soda than potash, and their most marked character is their deficiency in potash without any corresponding increase in soda content. For example, the world's average rhyolite has about 3½ per cent. of soda and 4 per cent. of potash, so in comparison the rhyolite in question has a normal soda content but is deficient to the extent of 2 per cent. of potash. The world's average basalt has about 3 per cent. soda and half that amount of potash, while the basalt here shows considerable deficiencies in both, more especially the potash.

If one compares the lime and magnesia contents it is found that they are about normal.

In comparison with the Cainozoic lavas of Southern Queensland, the Permo-Carboniferous rhyolite has higher alumina, lower lime, slightly higher soda, and much lower potash. The Permo-Carboniferous basalt, in comparison with the Cainozoic basalts, has higher alumina, lower total iron oxides, higher lime, and lower alkalies.

A comparison with the analyses of the volcanic rocks of the Southern Coalfield of New South Wales is made later in the paper.

TABLE I.—CHEMICAL ANALYSIS OF VOLCANIC ROCKS.

——	Rhyolite, Summit, Eight Mile Range, Portion 2161.	Rhyolite Tuff, Lucky Valley Creek, Portion 18v.	Andesite, Portion 1663, Eight Mile Creek.	Andesite, Portion 1663, Eight Mile Creek.	Basalt, Portion 2161, Eight Mile Range.
Analyst.	G. R. Patten.	G. R. Patten.	G. R. Patten.	G. R. Patten.	G. R. Patten.
SiO_2 ..	73·93	73·87	55·49	54·25	53·34
Al_2O_3 ..	16·85	12·92	18·63	19.46	18·73
Fe_2O_3 ..	0·60	nil.	1·89	3·16	1·72
FeO ..	1·10	2·32	5·41	4·27	6·65
MgO ..	0·43	0·83	3·28	2·75	5·10
CaO ..	0·63	2·83	6·09	5·81	8·75
Na_2O ..	3·61	3·23	4·11	3·56	2·30
K_2O ..	1·88	1·07	0·11	0·62	0·61
H_2O+ ..	0.47	0·43	2·16	2·19	1·03
H_2O- ..	0·15	0·09	0·17	0·22	0·21
CO_2 ..	nil.	1·75	1·19	1·97	nil.
TiO_2 ..	0·45	0·32	1·70	1.82	1·80
P_2O_5 ..	0·07	0·03	0·14	0.21	0·15
MnO ..	0·02	0·04	0·09	0·10	0·17
Total ..	100·19	99.73	100·45	100·39	100·56
Spec. Grav.	2·628	2·652	2·747	2·753	2·847

NORMS.

Quartz ..	43·74	47·04	14·40	19·56	9·00
Orthoclase	11·12	6·67	0·56	3·34	3·34
Albite ..	30·39	27·25	34·58	29·87	19·39
Anorthite	2·50	1·95	21·96	15·85	38·92
Corundum	8·06	5·61	3·67	7·14	..
Diopside	..	..	..	..	2.94
Hypersthene	1·89	5·80	13·88	9·14	19·32
Magnetite	0·93	..	2·78	4·64	2·55
Ilmenite	0·76	0·61	3·19	3·50	3·50
Apatite ..	0·34	0·34	0·34	0·34	0·34
Calcite ..	..	4·00	2·70	4·40	..
Water ..	0·62	0·52	2·33	2·41	1·24
Total ..	100·35	99·79	100·39	100·19	100·54
Classification	I.3.2.4.	I.3.1.4.	II·4.3.5.	II.4.3.5.	II.4(5).4.4

(IV.) COMPARISON WITH OTHER PERMO-CARBONIFEROUS VOLCANICS OF AUSTRALIA.

(*a*) *General.*—The volcanic series under discussion cannot be closely correlated with any similar series in Australia, and indeed this is one of the reasons for its

interest. However, it may be instructive to compare the Silverwood-Lucky Valley flows and tuffs with various other occurrences which have some features in common with them. It will be noted that where petrological comparisons reveal similarities, a consideration of the respective ages shows a lack of harmony, and on the other hand where the ages are in agreement the petrological characters are essentially different.

(*b*) *The Southern Coalfield of New South Wales.*—Harper has described a series of lavas and tuffs about 1,000 feet thick from the Cambewarra-Kiama districts, the age of which agrees closely with the Silverwood-Lucky Valley Series. "These consist of seven submarine" . . . . (followed by) . . . . "two terrestrial lava flows, intercalated with beds of Permo-Carboniferous age consisting mainly of volcanic tuffs."[3] Of these flows the "Blowhole Flow" "was apparently the first manifestation of volcanic activity in the shape of lava flows during the Upper Marine epoch, within the Southern Coalfield, and it is interbedded with tuffs containing marine fossils."[4] With regard to the uppermost "Minmurra Flow," Harper states that "The horizon occupied is about 120 feet above the top of the Cambewarra flow or its equivalent boulder horizon,"[5] which marks the upward limit of marine fossils. The Berkley Flow is also interbedded with the freshwater sediments overlying the Upper Marine.

This evidence forces on one the conclusion that the volcanics of the Southern Coalfield were practically contemporaneous with those of the Silverwood-Lucky Valley area, but here all resemblance ends. Chemically the two groups are essentially different, and this difference is reflected in the petrography. Harper describes the volcanics of the Southern Coalfield as "a petrographical province of Permo-Carboniferous age possessing definite chemical characters and notably a high potash content."[5] In the series under discussion the alkalies are not high, and soda predominates. This marked difference can best be

[3] Harper, L. F., Memoirs Geol. Sur. N.S.W., Geol. No. 7, p. 49.

[4] Harper, L. F., op. cit., p. 307.

[5] Harper, L. F., op. cit., p. 292.

[6] Harper, L. F., op. cit., p. 278.

appreciated by comparing analyses representative of the rocks of the two areas. The analyses used for the Southern Coalfield area are those quoted by Harper on page 284 of his memoir. These are eight in number. It will be noticed that the highest silica percentage in Harper's analyses is 59·64, while the majority of the flows in the Silverwood area are rhyolitic, and a typical analysis gives 73·93 percentage of silica. However, there is what in the light of modern petrogenesis must be considered an even more important chemical difference than the divergence in the average silica percentages, and that is the amount and proportion of the alkalies and lime present. In order to fairly illustrate this difference, the three analyses from the Silverwood-Lucky Valley volcanics which bear the closest resemblance in silica content to the Southern Coalfield rocks are compared with the eight available analyses from the latter area.

——	Extreme Values of Oxides of three Analyses from Silverwood—Lucky Valley.	Extreme Values of Oxides of eight Analyses from Southern Coalfield.
SiO_2	53·34—55·49	51·07—59.64
Al_2O_3	18·63—19·46	15·18—18·82
Fe_2O_3	1·72— 3·16	2·45— 7·30
FeO	4·27— 6·65	2·97— 5·40
MgO	2·75— 5·10	1·66— 4·09
CaO	5·81— 8·75	3·88— 7·72
Na_2O	2·30— 4·11	3·10— 3·97
K_2O	0·11— 0·62	2·75— 5·88
H_2O+	1·03— 2·19	1·07— 2·89
TiO_2	1·70— 1·82	0·42— 1·20
P_2O_5	0·14— 0·21	0·34— 0·88

The most striking difference in the two series is seen in the values for K_2O. The large amount of this oxide in the Southern Coalfield gives rise to the curious orthoclase-basalts and allied types in that area, which are in marked contrast with the volcanics with which we are concerned.

(*c*) *The Drake Area.*—The Drake area is of interest in the present connection for several reasons. It is the closest area which contains late Palæozoic volcanics comparable with those of the Silverwood-Lucky Valley district, being only some 50 miles distant. Lithologically the rocks of the

two areas have several points in common, and although the volcanics of the two areas appear to be somewhat different in age there is a parallelism in the sequence of their lavas.

The volcanics of the Drake area have been described in considerable detail by Andrews.[7] They "are referable to two distinct periods—an older, consisting mainly of rhyolites, and a younger, mainly of andesites." These in turn are succeeded by the Drake fossiliferous slates and tuffs, but "the whole, felsites and slates, were shown to belong to one great period of sedimentation."[8] Andrews further states that the fossils in the covering slates and tuffs "are of marine types and belong to the Lower Marine division of the Permo-Carboniferous period."[9] An early Permo-Carboniferous age thus seems to be indicated for the volcanics of this area.

The authors have examined specimens of the earlier Rhyolite Phase. These, while generally similar to the rhyolites of Silverwood-Lucky Valley, differed from them in the possession of veins of colloidal silica and in being somewhat mineralised (pyrites being fairly common). As neither rock analyses nor petrographical descriptions have been published, more detailed comparisons are at present impossible.

(*d*) *The Berseker Ranges, near Rockhampton.*—Through the courtesy of Mr. C. C. Morton, of the Queensland Geological Survey, the authors have had an opportunity of studying hand specimens regarded by Mr. Morton as typical of the great series of volcanics forming an important part of the Berseker Ranges. The rocks are closely comparable with those typical of the Silverwood-Lucky Valley volcanics. Mr. Morton believes them to be partly intrusive and partly volcanic, and states that they rest upon and intrude the Rockhampton series of Carboniferous age. Further evidence as to age is not forthcoming, but this close association of the volcanies with the Rockhampton series is suggestive of a Late Palæozoic age.

(*e*) *The Bowen River Coalfield.*—On the Bowen River Coalfield volcanic agglomerates associated with con-

[7] Andrews, E. C., Min. Res. N.S.W., No. 12, p. 11.
[8] Andrews, E. C., op. cit., p. 9.
[9] Andrews, E. C., op. cit., p. 14.

glomerates are developed, but these are very low down in the series. Dunstan regards them as belonging to the Lower Marine division of the Permo-Carboniferous, while Jensen believes them to be even older. In addition to these there is evidence of volcanic activity in this area in the shape of basalts interbedded with the Upper Marine strata. The age of these corresponds with that of the volcanics under discussion, but very little petrological evidence is available for purposes of comparison.

(*f*) *The Mackenzie River Area.*—In the Mackenzie River area, also, basalts interbedded with Upper Marine strata are known. Andesites, the horizon of which has not been definitely established, are found both in this and in the Dawson River areas.

(V.) EARTH MOVEMENTS AND IGNEOUS ACTIVITY.

The history of the Silverwood area may be briefly summarised as follows:—In Middle Devonian times extensive submarine outbursts resulted in the accumulation of a great thickness of andesitic tuffaceous material. This was immediately followed by the deposition of material which ultimately became a series of banded radiolarian cherts and mudstones. Pronounced orogenic movements in Late Devonian times (the Kanimbla Epoch of Süssmilch) compressed this "Silverwood Series" into isoclinal folds and elevated the Silverwood district into a land area, which it remained throughout the Carboniferous Period. During the latter part of this period very considerable igneous activity was in progress further to the south, in the New England district, but if the Silverwood area was also the scene of such activity there is no evidence of it. At the close of the Carboniferous period, and doubtless as the result of what in the New England area Süssmilch and David have described as the "Hunterian disturbance,"[10] the Silverwood area was depressed below sea-level, and fossiliferous strata equivalent to the Lower Marine of the Hunter River district were deposited. These seem normal sediments, for the most part laid down under shallow water, and show no signs of violent contemporaneous volcanic activity such as that which accompanied the accumulation of sediments of this age in the Drake area some 50 miles to

[10] Proc. Roy. Soc. N.S.W., 1919, p. 282.

the south. A slight change in sea-level resulted in the deposition of freshwater sediments (equivalent to the Greta Measures). Following this the area seems to have been subjected to a series of oscillatory movements, with the result that while the major portion of the sediments deposited are marine in nature (though of very shallow water types), there are intercalated with them at least two bands of freshwater deposits. The net result of these oscillations was a gradual change from marine conditions to terrestrial conditions, and it was during this change that the volcanic activity which is the subject of this paper was manifested; for while a considerable proportion of the lavas and tuffs are found associated with fossiliferous marine strata, the major portion of them shows evidence of having been poured out on a land surface. No further marine deposits have been laid down in the area from this time to the present day.

At some time subsequent to the deposition of the Upper Marine sediments and the associated volcanics, and antecedent to the deposition of the Ipswich Series (of Upper Triassic age), there were intruded the huge well-known granitic masses of New England and Southern Queensland. The representative of this group in the Silverwood area is the coarse acid Stanthorpe granite. This might, perhaps, be expected to show some evidence of relationship with the volcanics, but a comparison of chemical analyses shows important points of difference, for whereas the alkalies of the Stanthorpe granite are approximately equal, there is in the volcanic rocks a normal soda value which predominates over an abnormally low value for potash.

If we go a little further afield, however, we meet, at Greymare and elsewhere, with granitic rocks of a somewhat earlier phase than the acid Stanthorpe granite, which must therefore approximate even more closely in age the Permo-Carboniferous volcanics. One of us has endeavoured[11] to show that the late Palæozoic granitic rocks of Southern Queensland can be divided into an earlier "Grey Phase," characterised chemically by a marked predominance of soda over potash, and a later "Pink Phase," where the alkalies are approximately equal or have potash in excess of soda.

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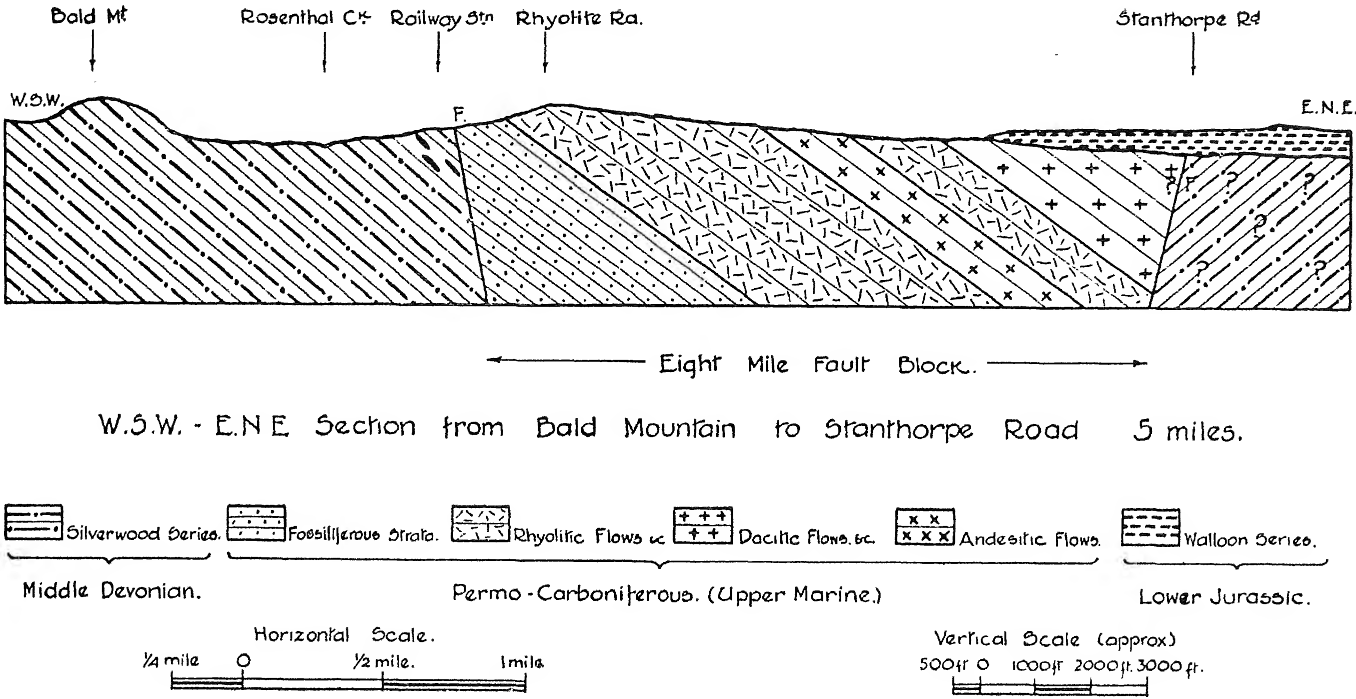
[11] Bryan, W. H., Proc. Roy. Soc. Qld., 1922, p. 148.

The earlier "Grey Phase" thus seems to be most nearly related to the volcanics under discussion, both in point of time and in chemical composition. The facts appear, then, to warrant the tentative assumption that the Permo-Carboniferous volcanics are genetically related to the granitic rocks of the "Grey Phase" as exemplified by the "Hornblendic, Dioritic, and other basic granites" of New England[12] and the "Maryland" and "Greymare" granites of the Stanthorpe area.

ACKNOWLEDGMENT.

The authors are indebted to Mr. R. A. Wearne, B.A., Principal of the Central Technical College, Brisbane, for providing facilities for the final drawing of the geological sketch section.

[12] Andrews, E. C., Records Geol. Sur. N.S.W., vol. viii., part 3, p. 212.



W.S.W. - E.N.E Section from Bald Mountain to Stanthorpe Road 5 miles.

PLATE IV.

Figure 1.—Rhyolite from Eight Mile Range, showing flow structures $\times \frac{1}{3}$.

Figures 2 and 3.—Rhyolites from Rhyolite Range, showing spherulitic structures $\times \frac{3}{4}$.

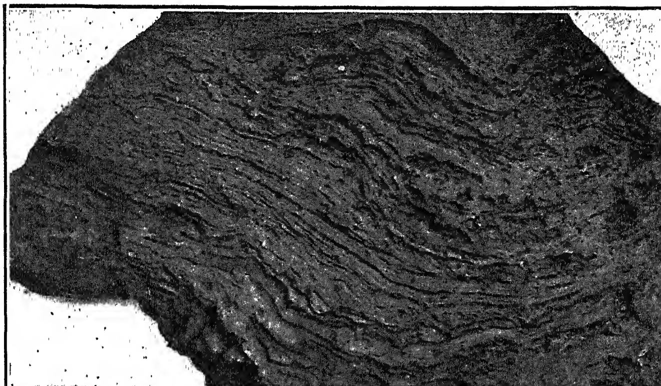


Fig. 1.

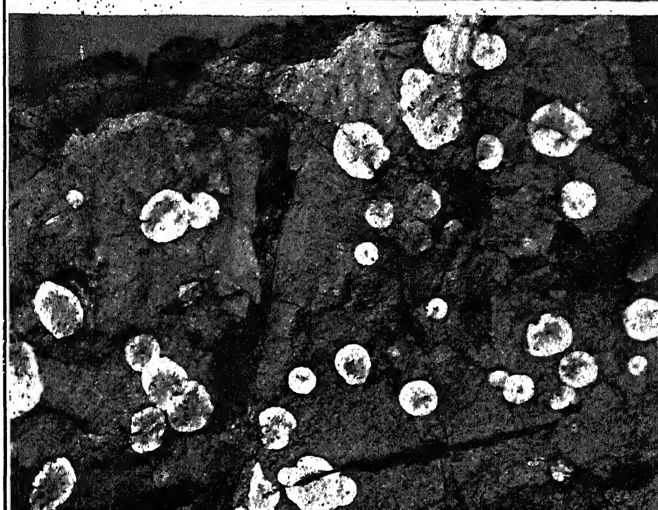


Fig. 2.

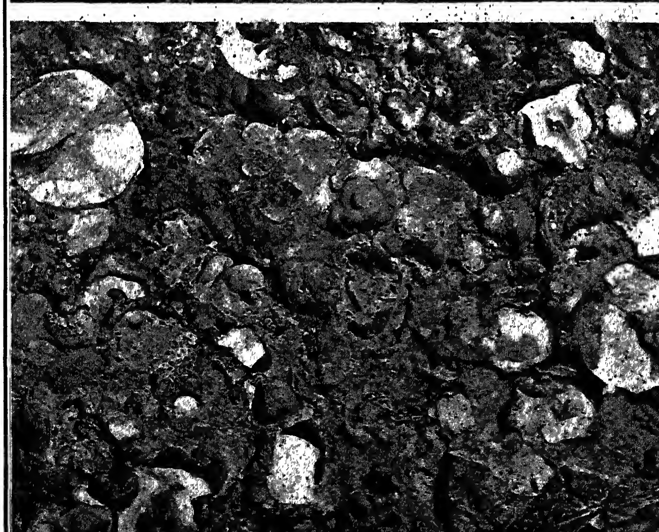


Fig. 3.

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The Queensland Inocerami Collected by M. Lumholz in 1881.

By F. W. Whitehouse, B.Sc., Foundation Travelling Scholar, Department of Geology, University of Queensland.

(Plates V.-VII.)

(*Read before the Royal Society of Queensland, 29th October, 1923.*)

Introduction.—The fossils about to be described constitute the collection of Inocerami made by Carl Lumholz from Minnie Downs, near Tambo, Queensland, in 1881, and subsequently deposited in the geological museum of the University of Kristiania. Several of the specimens were later transferred to the University of Lund.

I would take this opportunity of expressing my gratitude to Professors Kiaer, of Kristiania, and Grönwall, of Lund, for their kindness in placing the whole of the collection at my disposal. The examination of this material was undertaken in connection with a general revision of the Queensland Inocerami, the results of which are to be published some time later. Owing to the fact that the present forms represent a definite collection lodged outside Australia, it was deemed advisable to publish the following account separately. A redescription of the type of *I. maximus* Lumholz was found necessary since the account given by Lundgren[1] contains a very serious error.

The large specimen which constitutes the type of *I. maximus* was found weathered out from the matrix. The other specimens, however, were encased in a block of standstone which was subsequently sawn in two. The Kristiania portion, when it reached me, measured 14 ins. x 7 ins. x 6 in., and was crowded with large specimens of Inocerami with both valves in apposition in nearly every case. By permission a large number of these forms were removed from the matrix for description in this paper.

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[1] B. Lundgren: "On an Inoceramus from Queensland." *Bihang. till. K. Sven. Vet.-akad. Handl.*, B. II. No. 5, 1885, pp. 3-6, pl. I.

DESCRIPTION OF THE SPECIES.—The specimens examined form a related series characterised by (1) very slight inequality of the valves, (2) large size, (3) prominent pallial line and small sub-circular muscle scars, and (4) amazingly thin, relatively smooth shells. The type specimen of *I. maximus* measures 30 cms. along its greatest axis, yet its shell was only 1·5 mm. thick. A specimen of *I. scutulatus* attains a height of 10 cms. with a shell of 0·5 mm. thickness. Muscle scars are a feature extremely rarely seen in this genus, so that the presence of a prominent scar and pallial line on every specimen in this collection is of great interest.

INOCERAMUS MAXIMUS Lumholz.

(Pl. VII., figs. 1, 2*a*, and 2*b*.)

1885. *Inoceramus sp.* B. Lundgren, *Bihang. till. K. Sven. Vet.-akad. Handl.*, B. II., pp. 3-6, pl. I.

1889. *I. maximus.* C. Lumholz, "*Among Cannibals*" (London), p. 367, with text-fig.

Sp. Chars.—Shell attaining a large size, the outline being that of an oblique oval with a slightly curved axis. Somewhat inequivalve; very inequilateral, the umbones being terminal and the antero-dorsal area very sharply truncated. Postero-ventral angle regularly rounded. Height approximately equal to length; hinge line about one-third of the total length. Umbones acute, the left slightly more prominent than the right. Axis of growth gradually curving concave to the hinge line. Pallial area very marked, roughly parallel to the outline and occupying about one-third of the internal surface. Shell substance extremely thin. Ornamentation consists of concentric ribs, which are not very marked on the superior part of the shell and almost disappear on the ventral portion.

Obs.—The type specimen is a huge shell with the valves in apposition. Its dimensions are: Length 24 cms.; height 23 cms.; width (two valves together) 8·5 cms.; hinge-line about 7 cms.; thickness of shell substance 1·5 mm.

This specimen was originally described and figured by Lundgren in 1885.[2] Unfortunately in doing so he mistook

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[2] Lundgren, *Bihang, till. K. Sven. Vet-akad. Handl.*, B. II., pp. 3-6, pl. I.

the antero-dorsal margin for the hinge line, thereby confusing the terms left and right, and posterior and anterior. The description is thus very misleading; and the figure accompanying it, being orientated according to this error, gives a mistaken idea of the shell. It has therefore been necessary to redescribe it here. Lundgren's figure was of the left valve, and should be turned (in an anti-clockwise direction) through an angle of 80° for correct orientation. The right valve has been figured in this paper.

No specific name was given in the original description, but Lumholz[3] reprinted Lundgren's plate in his book, and labelled it *Inoceramus maximus*, which name was adopted by Etheridge Jr.,[4] and has been retained here. Etheridge endeavoured to identify specimens with this species relying on Lundgren's work, but owing to the original mistakes referred to above such identifications cannot be maintained.

INOCERAMUS SCUTULATUS sp. nov.

(Pl. V., fig. 1; pl. VI., fig. 1.)

Sp. Chars.—Shell inequilateral with a lozenge-shaped outline modified somewhat by the rounding of the angles. Height slightly greater than length. Hinge line very short, about a quarter length of the shell. Shell expanded almost equally on either side of the axis of growth. Umbones acute, terminal, and prominent. Pallial area sac-shaped, lunate, occupying about a quarter of the internal surface. Shell substance extremely thin, ornamented by concentric ribs which are not very prominent. Axis of growth at right angles to the hinge line, and with a slight tendency to curve towards the posterior. Ligament pits small.

Obs.—This species is distinguished by its lozenge-shaped outline and the sub-equal anterior and posterior expansions.

INOCERAMUS SCUTULATUS var.

(Pl. V., fig. 2; pl. VI., figs. 2 and 3.)

There are a number of forms, three of which are figured here, which, while differing among themselves, lie on a line of variation linking the two species *I. scutulatus* and *I.*

[3] Lumholz: "*Among Cannibals*" (London), p. 367.

[4] R. Etheridge, Jr.: *Geol. Surv. Q'land. Bull.*, 13, 1901, pp. 24-25.

maximus. The variation (considered, for the sake of description, as if proceeding from *scutulatus* towards *maximus*) begins in a rounding of the anterior and posterior median angles, thereby destroying the scutulate outline. At the same time the anterior portion of the shell decreases and the posterior tends to increase; while the growth oblique to the hinge line becomes more marked.

I have refrained from attaching a definite varietal name to cover these forms; for, with the available information, and especially considering the lack of knowledge of the stratigraphical distribution, I cannot make up my mind how to place them. Two methods suggest themselves as being the most probable—

(1) That these forms linking the two extremes of *I. scutulatus* and *I. maximus* form a variety of the same kind as *I. concentricus* var. *subsulcatus*[5] (which links the two forms *I. concentricus* and *I. sulcatus*) ; or

(2) That the definition of *I. scutulatus* should be extended to cover forms like pl. VI., fig. 2, and *I. maximus* should similarly be enlarged to include forms such as pl. V., fig. 2, and pl. VI., fig. 3.

Thus until further information is available I prefer to leave the intermediate forms in an unnamed variety intermediate between the two species as defined above.

INOCERAMUS PROCERUS sp. nov.

(Pl. VI., fig. 4.)

Sp. Chars.—Shell oval, erect, inequilateral, slightly inequivalve. Height much greater than length (ratio 3 : 2). Hinge line about half the length of shell. Umbones terminal, acute, very prominent. Anterior portion sharply truncate, posterior flattened and sub-alate. Ornamentation (in adult specimens) consists of widely separated concentric ribs only on the earlier parts of the shell, the later parts being smooth. Test very thin. Ligament pits small. Pallial area occupying about one-third of the internal surface.

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[5] *See* H. Woods: "The evolution of Inoceramus in the Cretaceous period," *Q.J.G.S.* LXVIII., 1912, p. 4.

Obs.—This species is distinguished by its erect habit. The hinge line is longer than in either of the two species described above. The area within the pallial line is about the same as in *I. maximus*, but the direction of the axis of growth and only slight axial curvature ally it rather to *I. scutulatus*. Probably both this species and *I. maximus* represent off-shoots from *I. scutulatus*.

COMPARISON WITH OTHER SPECIES.—*I. scutulatus* may be closely compared with the short form of *I. crippsi* var. *reachensis* Eth.[6] from the Cenomanian of England. Both species have the subequal anterior and posterior expansions of the valves, and there is a certain scutulate outline, but much less pronounced, in the latter variety. It differs from the English form in having the umbones more prominent, the hinge line shorter, and the concentric ornamentation much less pronounced.

I. maximus shows a pronounced resemblance to the widespread *I. labiatus*[7] (Schloth.) (Cenomanian and L. Turonian), which is also a large form. The resemblance is most apparent in the direction of growth oblique to the hinge line (a characteristic feature of *I. labiatus*). It differs from this form particularly in the more-acute umbones and the less-prominent ornamentation.

Eichwald[8] figures a specimen labelled *I. mytiloides* from the Cretaceous of Russia, which very closely resembles the original of pl. V., fig. 2, of this paper. (*I. mytiloides*, it is to be noted, is regarded by Woods as a synonym of *I. labiatus*.) Again, the Queensland form differs in the more-pronounced umbones and less-prominent ornamentation.

Woods has shown[9] for the English forms that *I. labiatus* has most probably evolved direct from *I. crippsi* var. *reachensis*, and it is thus interesting to note that *I. scutulatus* and *I. maximus*, which are themselves connected by intermediate forms, are individually comparable with

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[6] *See* H. Woods: "*Monogr. Cret. Lamellibr.*" (Palæont. Soc.), vol. II., 1911, p. 278, pl. XLVIII., fig. 5; pl. XLIX., fig. 1.

[7] *See* Woods, *op. cit.*, pp. 281-284, pl. L.

[8] Eichwald, "Lethæa Rossica" (per. moyenne), pl. XXI., fig. 6.

[9] Woods, "The evolution of Inoceramus in the Cretaceous period," *Q.J.G.S.* LXVIII., 1912, p. 13.

these two English species. I cannot regard the Queensland forms as identical with the European species, for all specimens show the consistent distinctive features noted above. It remains to be seen whether these species will show the same stratigraphical distribution as the European forms.

Further comparisons are held over until, in a later paper, the Queensland Inocerami are treated as a whole. But it may be noted that in these particular species I find no very close relationships with Indian or New Zealand forms.

These collections return, of course, to the Universities of Kristiania and Lund; but plaster casts of the types will be brought to Queensland.

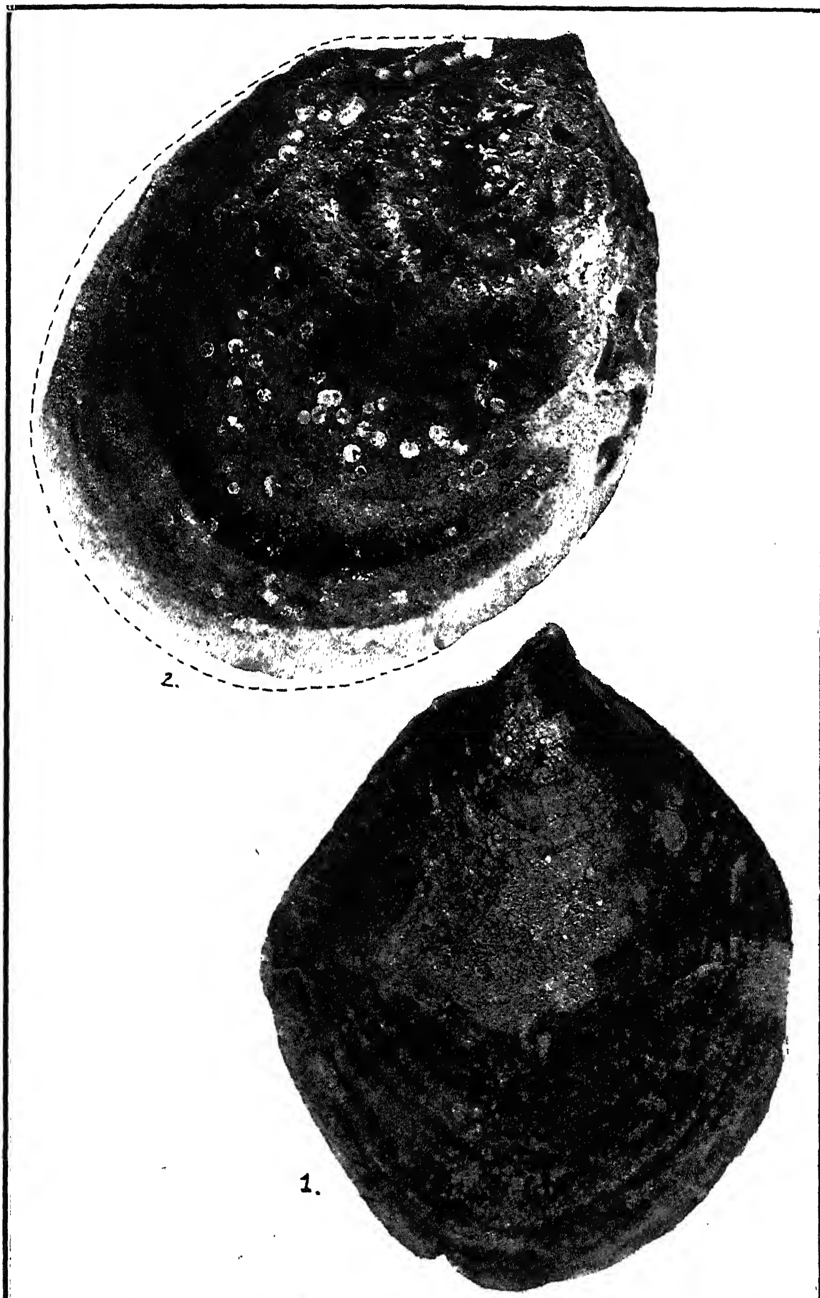

Fig. 1.—*Inoceramus scutulatus* Whitehouse. Right valve of type specimen, × $\frac{4}{5}$ (Kristiania collection).

Fig. 2.—*Inoceramus scutulatus* var. Right valve of a specimen closely approaching *I. maximus*, × $\frac{4}{5}$ (Kristiania collection).

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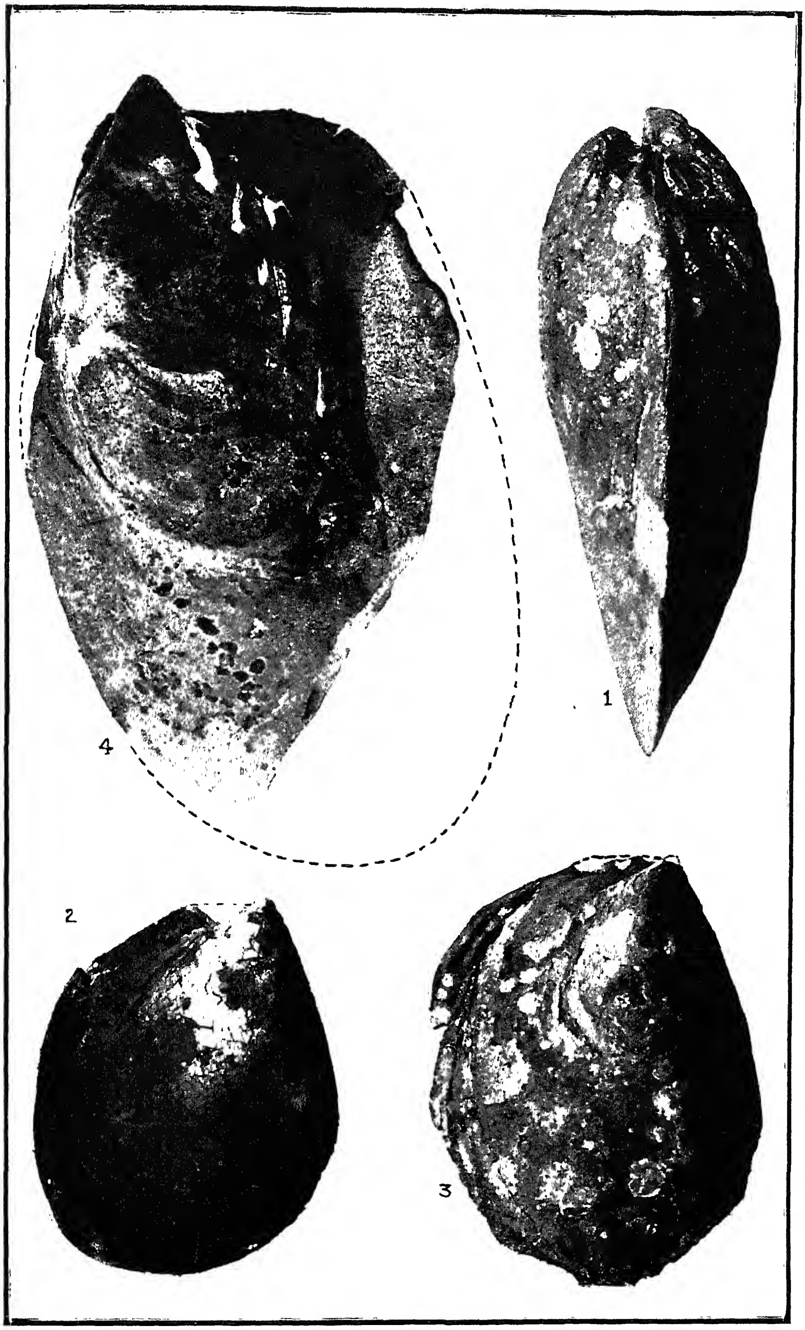
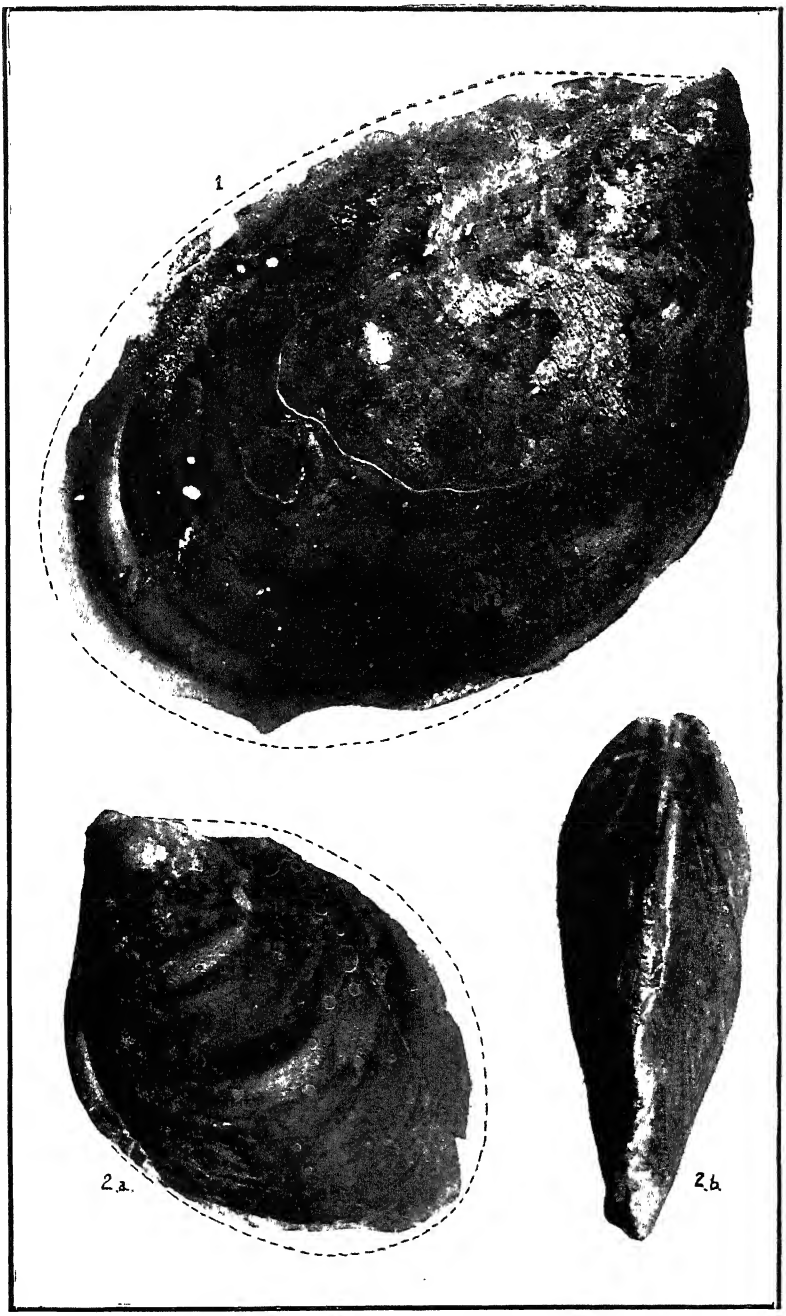


Fig. 1.—*Inoceramus scutulatus* Whitehouse. Anterior view of Pl. V., fig. 1, $\times \frac{4}{5}$.

Figs. 2 and 3.—*Inoceramus scutulatus* var. Two small right valves, $\times \frac{4}{5}$. Fig. 2 approaches the normal type of *I. scutulatus*.

Fig. 4.—*Inoceramus procerus*, Whitehouse. Left valve of type specimen, approx. $\times \frac{1}{2}$.

Face page 132.



Inoceramus maximus Lumholz. Fig. 1—Right valve of type specimen, × $\frac{2}{5}$ (Kristiania collection). Fig. 2—Smaller specimen, × $\frac{4}{5}$ (Lund collection); *a*, left valve; *b*, antero-ventral view.

Face page 132.

The Composition of the Volatile Oil of the Leaf of *Daphnandra aromatica* Bailey.

By T. G. H. JONES, B.Sc., A.I.C., and FRANK SMITH, B.Sc., F.I.C.

(*Read before the Royal Society of Queensland, 26th November, 1923.*)

SUBSEQUENT to the publication of our note (this volume, pp. 61-2) on the essential oils from the bark and leaves of *Daphnandra aromatica*, we received from North Queensland through the courtesy of Mr. E. H. F. Swain, Director of Forests, a further supply of leaves permitting of chemical examination in detail of their volatile oil.

Contrary to expectation from the cursory examination of the small amount of leaf oil (40 ccs.) previously available, limonene was not found to be present in the lower boiling fractions of the oil.

The principal constituents of the oil are d*a*-phellandrene and a sesquiterpene; the other bodies present being d-pinene, cineol and a sesquiterpene alcohol together with small quantities of an aldehyde (probably iso-valeric or caproic) and a phenolic body.

In view of the present inexact condition of knowledge of the sesquiterpene group and of the scantiness of the data secured, it is not possible to decide whether the sesquiterpene and the sesquiterpene alcohol of Daphnandra leaf oil are each distinct chemical entities or are identical or not with any similar bodies previously described.

Experimental.—The distillation in steam of 200 lbs. of air-dried leaves yielded 400 ccs. or ·5 per cent. of a pale-yellow oil of agreeable odour possessing the following constants:—

Specific gravity $\frac{15{\cdot}5}{15{\cdot}5}$ ·9084 $(N)_{D20}$ 1·4892 $(a)_D + 23{\cdot}6$.
Ester value 10, Acetyl value 40.

Five ccs. of the oil were extracted in turn with sodium bisulphite and with sodium hydroxide solutions. Absorption to the extent of about 1 per cent. of an aldehydic body and ·5 per cent. of a phenolic body giving a greenish colour with ferric chloride were recorded.

On fractionation of 370 ccs. of the oil at 2 mms. pressure, using an oil pump with a trap cooled in liquid ammonia interposed between the pump and receiver, there were collected—

(1)	In ammonia trap	.. ..	10 ccs.
(2)	Below 50° C ..	.. ..	91 ccs.
(3)	At 50– 60° C	.. ..	46 ccs.
(4)	At 60– 70° C	.. ..	15 ccs.
(5)	At 70– 80° C	.. ..	20 ccs.
(6)	At 80–100° C	.. ..	108 ccs.
(7)	At 100–115° C	.. ..	25 ccs.
(8)	At 115–128° C	.. ..	40 ccs.,

leaving a small viscous residue in the distilling flask.

The presence of cineol was indicated in the lower fractions by its odour, and fractions (2), (3), (4), (5), and (6) were accordingly extracted several times with 50 per cent. resorcin solution.

The unabsorbed oil in these fractions was then refractionated at 21 mms. pressure, and the following fractions ultimately collected:—

(9) Boiling below 65° C.
15 ccs. Sp. Gr. ·861 $(N)_{D20}$ 1·466 $(a)_D$ + 50

(10) Boiling at 65°–68° C.
60 ccs. Sp. Gr. ·8538 $(N)_{D20}$ 1·4745 $(a)_D$ + 59

d-Pinene.—The physical constants as well as the odour of fraction (9) suggested the presence of pinene, although the presence of phellandrene was also indicated by the nitrosite reaction. It did not, however, yield the nitrosyl chloride characteristic of pinene (owing, no doubt, to its high degree of optical activity), but the presence of pinene was confirmed by oxidation with potassium permanganate solution.

Five ccs. of the oil were shaken with 10 grammes of potassium permanganate and 150 ccs. of water and 100

grammes of ice until the permanganate was completely reduced. The liquid was then filtered from the manganese dioxide and evaporated to small bulk. Small amounts of neutral oxidation products were extracted with ether and the liquid then acidified with dilute sulphuric acid and again extracted with ether.

On evaporation of the ether the remaining liquid (about 4 ccs.) was identified as pinonic acid by means of its semi-carbazone melting at 204° C, and pinene was therefore present in the fraction.

The fraction (1) collected in the ammonia trap also consisted largely of pinene, but the presence of an aldehyde was indicated by Schiff's Reaction. Attempts were made to extract it by means of semi-carbazide hydrochloride, but the small amount of material obtained prevented purification of the resulting semi-carbazone. The irritating and unpleasant odour, however, would suggest identity with isovaleric or caproic aldehyde.

dα-Phellandrene.—Fraction (10) consisted largely of dα-phellandrene. It was identified as such by means of its nitrosite prepared in accordance with the method described by Smith, Hurst, and Read (J.C.S. Transactions, 1923, 1657). The resulting nitrosite melted at 120-121° C.

Cineol.—The oil extracted by the resorcin solution (described above) was recovered by distillation in steam, and found to consist almost exclusively of cineol. It was identified as such by its physical constants Sp. Gr. 9330, $(N)_{D20}$ 1·458, as well as by its characteristic odour.

Sesquiterpene.—It was evident from analysis that fraction (6) consisted largely of a sesquiterpene. It was refractionated and finally redistilled repeatedly (at the reduced pressure) over metallic sodium. B.P. 110-111°C (4 mms.) 146-148°C (24 mms.).

(Found C = 87·7%. H = 11·4%. $C_{15}H_{24}$ requires C = 88·2. H = 11·8).

Sp. Gr. $\frac{15·5}{15·5}$ ·9106 $(N)_{D20}$ 1·5012 $(\alpha)_D + 2·7$.

Molecular refraction 66 (calculated 62·6 for $C_{15}H_{24}$).

None of the solid derivatives used to characterise many known sesquiterpenes could be prepared. A liquid hydrochloride was obtained by passing dry HCl gas into its ethereal solution (cooled with ice), and the nitrosyl chloride and nitrosite were also apparently liquid. The molecular refraction indicated probable di-cyclic character, and that it contained two double bonds.

Treated with a few drops of glacial acetic acid and bromine vapour a violet colour was developed, rapidly turning deep-blue.

Sequiterpene Alcohol.—Fraction (8) was a viscid liquid of a light-green colour. Sp. Gr. $\frac{15\cdot5}{15\cdot5}$ ·9666 $(N)_{D20}$ about 1·50. Boiling point 170-180° C (24 mms.). Its alcoholic character was demonstrated by its action on metallic sodium and reaction with acetic anhydride.

Summary.—The air-dried leaves of *Daphnandra aromatica* yielded on distillation with steam ·5 per cent. of a light-yellow oil possessing an agreeable aromatic odour, the composition of which is indicated as approximately d-pinene 5-10 per cent., d*a*-phellandrene 20-25 per cent., cineol 10-15 per cent., sesquiterpene 30-40 per cent, sesquiterpene alcohol 5-10 per cent., with minor aldehydic phenolic and ester constituents.

THE

ROYAL SOCIETY OF QUEENSLAND

ABSTRACT OF PROCEEDINGS

Report of Council for 1922.

To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting its Report for the year 1922.

During the year twelve papers were published. With a few exceptions, these papers were read before the Society. In addition, the following lectures, which were well attended and to which the public was invited, were delivered: "The Geology of Northern Australia," by Dr. H. I. Jensen; "Kosciusko, the Roof of Australia," Professor H. C. Richards; "The Eucalypts of the Brisbane District," C. T. White; and "Corals," Professor F. Wood-Jones. The last-mentioned lecture was held in conjunction with the Royal Geographical Society of Queensland.

The Society is indebted to the University of Queensland for providing accommodation for meetings and for housing the library.

We wish to acknowledge the practical assistance afforded the Society by the Government of Queensland, who, as in previous years, voted £50 towards the Society's activities. Appreciative acknowledgment is also accorded to the Government of Papua for a subsidy of £25 towards the printing of Mr. C. T. White's paper on the Flora of Papua and to the Walter and Eliza Hall Fund for subsidies towards the publication of the following papers: "Notes on the Biology of Some of the More Common Queensland Muscoid Flies," by T. H. Johnston and O. W. Tiegs, "New and Known Sarcophagid Flies" by T. H. Johnston and O. W. Tiegs, and "A Synonymic List of Some Described Calliphorine Flies" by T. H. Johnston and G. H. Hardy.

The membership roll consists of 84 ordinary members, 9 life members, 10 corresponding members, and 3 associate members. During the year 8 new members were elected, and one member resigned.

With deep regret we record the deaths since last annual meeting of two of our members, namely, Dr. A. Sutton, C.B., C.M.G., and Mr. J. Johnston.

Eight meetings of the Council were held during the year. The attendance was as follows: H. J. Priestley (President) 7, E. W. Bick 8, W. H. Bryan 6, W. D. Francis 7, E. H. Gurney 6, T. H. Johnston 3, H. A. Longman 5, E. O. Marks 8, H. C. Richards 4, E. H. Swain 4, C. T. White 7.

Attention is drawn to the accompanying Statement of Receipts and Expenditure, which shows that the Society's funds are almost exclusively devoted to printing.

H. J. PRIESTLEY, *President.*

W. D. FRANCIS, *Hon. Secretary.*

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The Society was represented by Professor H. C. Richards, D.Sc., at the meeting of the Australasian Association for the Advancement of Science held at Wellington from 10th to 18th January, 1923. In the report which Professor Richards submitted to the Council, it is stated that it was decided to have the next meeting of the Association at Adelaide in August, 1924.

CORRIGENDUM.

On page 2, Proceedings of this Society for 1922 (Vol. XXXIV.), in paragraph referring to the death of Dr. J. Shirley, 12th line from bottom of page, for "5th March" read "4th April."

THE ROYAL SOCIETY OF QUEENSLAND.

Cr. STATEMENT OF RECEIPTS AND EXPENDITURE FOR YEAR ENDING 31ST DECEMBER, 1922. **Dr.**

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
Bank Balance, 31st December, 1921	35	5	7	Printing, Government Printer	224	5	9
Subscriptions	87	13	6	Hon. Secretary (Petty Cash)	10	0	0
Queensland Government Subsidy	50	0	0	Hon. Librarian (Petty Cash)	0	10	0
Papuan Government Subsidy towards cost of printing "Contribution to Our Knowledge of Papuan Flora"	25	0	0	Advertising	2	2	0
Subsidy, printing Fellowship Papers (Walter and Eliza Hall Trust Fund), Queensland University	42	10	0	Insurance	0	18	0
Extra copies of Papers and Blocks	25	11	0	Lanternist	1	0	0
Cheques drawn, not presented at 31st December	3	2	0	Barrier Reef Committee	2	2	0
Exchange	0	1	0	Exchange	0	1	10
				Bank Charge	0	10	0
				Balance in Bank, 31st December, 1922 ..	27	13	6
	£269	3	1		£269	3	1

Examined and found correct.

H. J. PRIESTLEY,
Hon. Auditor, 27th February, 1923.

E. W. BICK,
Treasurer.

ABSTRACT OF PROCEEDINGS, 26TH MARCH, 1923.

The Annual Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 26th March, 1923.

His Excellency Sir Matthew Nathan, P.C., G.C.M.G., Patron of the Society, presided.

The minutes of the previous Annual Meeting were confirmed.

Drs. R. W. Cilento and S. Fancourt McDonald were unanimously elected as Ordinary Members.

Archbishop Duhig, Professor E. J. Goddard, B.A., D.Sc., Professor J. P. Lowson, M.A., M.D., G. P. Dixon, C.B.E., M.B., Ch.M., J. G. Hamlin, M.Sc., Mrs. Hamlin, M.A., Miss Barker, B.A., were proposed as Ordinary Members, and J. H. Simmonds, B.Sc., and F. G. Holdaway, B.Sc., were proposed as Associates.

On the motion of Prof. Richards, seconded by Mr. Longman, the Annual Report of the Council and the Statement of Receipts and Expenditure were adopted.

The following officers were elected for 1923:—

President: Dr. E. O. Marks, M.D., B.A., B.E.

Vice-Presidents: Prof. H. J. Priestley, M.A. (*ex officio*); W. H. Bryan, M.Sc.

Patron: His Excellency Sir Matthew Nathan, P.C., G.C.M.G.

Hon. Secretary: W. D. Francis.

Hon. Treasurer: E. W. Bick.

Hon. Editor: H. A. Longman, F.L.S.

Hon. Librarian: W. H. Bryan, M.Sc.

Hon. Auditor: Prof. H. J. Priestley, M.A.

Members of Council: E. H. Gurney, Professor H. C. Richards, E. H. Swain, R. A. Wearne, B.A., and C. T. White, F.L.S.

The retiring President, Prof. H. J. Priestley, M.A., delivered his presidential address entitled, "On the Development of Scientific Thought."

A cordial vote of thanks to His Excellency the Governor was carried by acclamation.

ABSTRACT OF PROCEEDINGS, 30TH APRIL, 1923.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 30th April, 1923.

The President, Dr. E. O. Marks, M.D., B.A., B.E., in the chair.

The minutes of the previous Monthly Meeting were read and confirmed.

Drs. J. Lockhart Gibson, T. W. H. Mathewson, and E. N. Merrington, Rev. C. H. Massey, and Mrs. E. Lumley Hill were nominated for ordinary membership.

Archbishop Duhig, Professor E. J. Goddard, B.A., D.Sc., Professor J. P. Lowson, M.A., M.D., G. P. Dixon, C.B.E., M.B., Ch.M., J. G. Hamlin, M.Sc., Mrs. Hamlin, M.A., Miss Barker, B.A., were elected as Ordinary Members, and J. H. Simmonds, B.Sc., and F. G. Holdaway, B.Sc., were elected as Associates.

In making an exhibit of specimens, drawings, and slides of Queensland fossil insects, Mr. B. Dunstan gave a general account of the insect-bearing beds of Denmark Hill, Ipswich District. These beds were discovered by Mr. J. H. Simmonds when looking for fossil plants. Many years afterwards they were carefully investigated by officers of the Queensland Geological Survey. Illustrations of very old types of the dragon-fly, mantis, locust, lacewing, cockroach, bug, jassid, and beetle were screened. One slide showed a restoration of *Ipsvicia Jonesi,* a giant jassid, named after the Minister for Mines. This restoration was made possible by the recent discovery of an almost perfect specimen. The insect quarry at Ipswich has yielded about 120 new species of fossil insects, and no doubt others will be unearthed as the investigation proceeds.

Mr. W. H. Bryan, M.Sc., communicated a paper by Dr. R. J. Tillyard, M.A., D.Sc., F.E.S., entitled "On a Tertiary Fossil Insect Wing from Queensland." The paper describes a new insect discovered by Mr. Bryan in the Tertiary beds at Redbank Plains, near Goodna. One other fossil insect wing (*Euporismites balli*) has been found in the same deposits, and described by Dr. Tillyard, while numerous fossil fish and dicotyledonous plants have been found on the same horizon. The new insect wing has been

named *Scolypopites bryani*, n.g. et sp., the generic name indicating its close affinity to the recent Australian genus *Scolypopa,* the common passion-vine hopper of Eastern Australia, to which it is probably directly ancestral, and the specific name being a dedication to its discoverer. Prof. Richards, Mr. Tryon, Prof. Goddard, Dr. A. J. Turner, and Mr. Bryan took part in the discussion on the paper and Mr. Dunstan's exhibits.

Mr. G. H. Hardy read a paper by Prof. T. H. Johnston and himself, entitled "Observations Regarding the Life Cycle of Certain Australian Blowflies," and gave an account of some of the work he was engaged upon as a Walter and Eliza Hall Fellow. The work of the Fellowship consisted chiefly of experimental investigation of the biology of blowflies. It had been discovered that a batch of these flies bred under uniform conditions varied greatly in the period of the life cycle, particularly in the prepupal stage, and it was pointed out that chalcid wasps with suitable habits in other parts of the world might be introduced into Australia to supplement those already preying upon the sheep maggot flies here.

Abstract of Proceedings, 28th May, 1923.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 28th May, 1923.

The President, Dr. E. O. Marks, M.D., B.A., B.E., in the chair.

The minutes of the previous Monthly Meeting were read and confirmed.

J. Lockhart Gibson, M.D., T. H. R. Mathewson, M.B., Ch.B., E. N. Merrington, Ph.D., Mrs. E. Lumley Hill, and Rev. C. H. Massey were elected as Ordinary Members.

A paper by Mr. John C. Hamlin, M.Sc., entitled "New Cactus Bugs of the Genus Chelinidea (Hemiptera)," was tabled and taken as read. Two new species and one new variety are described in the paper. These insects were collected by the author in North America for the purpose of endeavouring to control prickly-pear in Australia by biological agencies.

A paper by Dr. T. L. Bancroft entitled "Some Further Observations on the Dawson River Barramundi: *Scleropages leichhardtii*," was communicated by the Hon. Secretary. The author concludes that the following facts have been ascertained:—Barramundi carries the spawn in its mouth; October is the spawning season; fish when meshed, eject the spawn; sexually mature fish are not meshed in a net of 3-inch mesh; fish secured in the bunt of a drag-net would retain the ova and young fish in their mouths.

Mr. W. H. Bryan, M.Sc., read a paper entitled "An Unusual Tourmaline-albite Rock from Enoggera, Queensland." This curious rock, found by Mr. Bryan near the contact of the Enoggera granite with the Brisbane schist, is composed entirely of tourmaline and albite. It shows a pronounced schistose structure. The only other rock of the same constitution previously described is found in Cornwall, England.

The President exhibited specimens of carbonaceous earth found at Samford where a bush fire had ignited it. The earth continued to burn for some week afterwards, and deposited a substance with the appearance of baked clay.

The President, Messrs. F. Bennett, R. A. Wearne, and W. H. Bryan took part in the discussion on the papers.

Abstract of Proceedings, 27th June, 1923.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Wednesday, 27th June, 1923.

The President, Dr. E. O. Marks, B.A., B.E., M.D., who was in the chair, announced that His Excellency, Sir Matthew Nathan, had expressed his regret at being unable to attend through indisposition.

The minutes of the previous monthly meeting were read and confirmed.

A paper by T. G. Jones, B.Sc., A.I.C., and F. B. Smith. B.Sc., F.I.C., entitled, "Notes on the Essential Oil of

Daphnandra aromatica," was tabled and taken as read. Chiefly the oil of the bark, which contains 95 per cent. of safrol, is dealt with.

Mr. H. A. Longman, F.L.S., delivered a lecture entitled, "Australian Marsupials," illustrating his remarks with specimens and lantern slides. Although species of large macropods were at present so numerous as to be pests in many Western districts, a plea was made for fenced inland reserves—including one by the main railway—for their special protection. The lecturer stated that the fossil marsupial fauna was even more characteristically Australian than that of to-day, and the evolution of the group had largely taken place here. He thought that fossil evidence would one day be forthcoming for the northern origin of remote ancestors.

A vote of thanks was accorded the lecturer on the motion of Dr. J. V. Duhig, seconded by Mr. R. A. Wearne. Mr. H. Tryon and Mr. Donald Gunn (a visitor) took part in the discussion.

The Ordinary Monthly Meeting of the Society will be held in the Geology Lecture Theatre of the University at 8 p.m. on Tuesday, 24th July.

Abstract of Proceedings, 24th July, 1923.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Tuesday, 24th July, 1923.

The President, Dr. E. O. Marks, B.A., B.E., M.D., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. F. B. Guthrie, F.I.C., was nominated for Ordinary Membership.

The Council's appointment of Prof. E. J. Goddard, B.A., D.Sc., as Hon. Librarian was ratified on the motion of Mr. P. Sylow, seconded by Prof. Richards.

On the motion of Prof. Richards, seconded by Mr. Longman, the Society's appreciation was accorded Mr. W. H. Bryan, M.Sc. (Vice-President), for his work as Hon. Librarian.

Mr. H. A. Longman, F.L.S., exhibited two skins of pouch embryos of the grey kangaroo (*Macropus giganteus*), which had been taken from one mother by Mr. H. S. Smith of Morven, and sent to the Queensland Museum. One skin was quite naked, whilst the other was considerably larger and thinly haired. Although it was just possible that the kangaroo may have acted as foster mother to the larger pouch embryo, it seemed probable that this was a case of supplementary twins, such as that recorded in the Proceedings of the Zoological Society, 1912, page 234.

Mr. C. T. White, F.L.S., read a paper, by himself and W. D. Francis, entitled "Contributions to the Queensland Flora, Part II." One new genus (*Placospermum*, Nat. Order Proteaceæ) and nine new species are described. The new species are *Calophyllum touriga, Aglaia ferruginea, Eugenia macrohila, Eugenia Petriei, Ardisia bifaria, Cryptocarya foveolata, Cryptocarya pleurosperma, Placospermum coriaceum* and *Croton densevestitum*. Sixteen species are recorded for the State for the first time. Mr. Longman discussed the paper.

In communicating his paper entitled, "Notes on the Physiography of Eastern New Guinea and Surrounding Island Groups," Rev. C. H. Massey delivered a lecture on the subject. He described the geological features of the Rabaul Harbour and the country within a 20-mile radius. The recent volcanic disturbances in that area were referred to, and the lecturer correlated the predominant mountain ranges of Eastern New Guinea and New Britain with the ocean basins of the South-Western Pacific.

A vote of thanks was accorded the lecturer on the motion of Prof. Richards, seconded by Mr. W. H. Bryan, and supported by the President and Mr. L. C. Ball.

Owing to the absence of a large number of the active members of the Society, the August Monthly Meeting was not held.

ABSTRACT OF PROCEEDINGS, 24TH SEPTEMBER, 1923.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 24th September, 1923.

The President, Dr. E. O. Marks, B.A., B.E., M.D., in the chair.

The minutes of the previous Monthly Meeting were read and confirmed.

Dr. F. W. S. Cumbrae-Stewart, B.A., Prof. T. Parnell, M.A., and Mr. T. W. Heney were nominated for membership

Mr. F. B. Guthrie, F.I.C., was unanimously elected as an ordinary member.

Specimens of the Quetta "meteorite" were exhibited on behalf of Prof. Skertchly. The exhibit was commented upon by Prof. Richards.

Prof. H. C. Richards, D.Sc., read a paper by himself and Mr. W. H. Bryan, M.Sc., entitled "Permo-Carboniferous Volcanic Activity in Southern Queensland." A series of lavas and tuffs met with in the Silverwood-Lucky Valley area are dealt with in the paper. These rocks, on account of their resistance to weathering, are the dominating topographic forms in their immediate locality, and in some cases act as important divides. One outcrop measured 4,250 ft. in minimum thickness, and the authors have reasons for assuming that the total thickness is much greater. Both the flows and the associated pyroclastic rocks are for the most part of an acid nature, and many beautiful examples of spheroidal and fluidal rhyolites were observed. More basic volcanics are represented in the upper part of the series, but in smaller amount.

A vote of thanks was accorded the authors on the motion of Mr. L. C. Ball, B.E., seconded by Dr. H. I. Jensen, and supported by Mr. Gurney and the President.

ABSTRACT OF PROCEEDINGS, 29TH OCTOBER, 1923.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 29th October, 1923.

The President, Dr. E. O. Marks, B.A., B.E., M.D., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Dr. Cumbrae-Stewart, Mr. T. W. Heney, and Professor T. Parnell, M.A., were unanimously elected as ordinary members.

Mr. W. B. Alexander, M.A., exhibited pellets produced by the Boobook Owl, "Laughing Jackass," Wedge-tailed Eagle, and Australian Crow collected by him in the Rockhampton district. He stated that though it had long been known that owls ejected from the mouth pellets of bones and fur, it had only recently been discovered that some Australian Kingfishers had a similar habit, and it had not hitherto been known that eagles and crows produced pellets. Those of the crow exhibited were of special interest because they contained numerous seeds of prickly-pear, thus indicating conclusively that these birds spread that plant.

Professor E. J. Goddard, B.A., D.Sc., exhibited specimens of *Peripatus capensis,* which, he explained, was the classic subject worked upon by Professor Sedgwick. It is the finest species of the genus and is distributed in the West Indies, Brazil, South Africa, India, East Indies, Australia, and New Zealand. Like so many other forms of the Southern hemisphere it is a primitive type, and its distribution has been much abused by zoogeographers.

The President exhibited specimens of hollow calcareous nodules containing drusy cavities, which were found in sandstone near Ipswich, and a cylindrical stone implement of unusual shape, which had been ploughed up near Taroom, and sent in by Mr. A. H. Blackman. This would be placed in the Queensland Museum.

Mr. W. H. Bryan, M.Sc., communicated a paper entitled, "The Queensland Inocerami, collected by Lumholz in 1881," by F. W. Whitehouse, B.Sc., Foundation Travelling Scholar, Department of Geology, University of Queensland. In the paper the author describes the results of his re-examination of the Inocerami which were collected by Lumholz from Minnie Downs, near Tambo, in 1881, and subsequently deposited in the University of Kristiania.

The examination of this material was undertaken in connection with a general revision of the Queensland Inocerami. The author redescribes the type of *I. maximus* Lumholz, describes two new species, *I. scutulatus* and *I. procerus*, and compares these with European and other species. Professor Richards commented upon the paper.

Dr. A. Jefferis Turner, M.D., opened a discussion on the origin of the Australian Fauna. Professors Goddard and Richards, and Messrs. Longman, Bryan, Alexander, Bennett, and Hardy took part in the discussion.

Two public lectures by Professor J. Cossar Ewart, F.R.S., of the Edinburgh University, were held under the auspices of the Society. One, entitled "The History of Feathers and the Breeding of King Penguins," was held on 17th October. His Excellency Sir Matthew Nathan, P.C., G.C.M.G., presided. A vote of thanks was accorded the lecturer on the motion of Dr. J. Lockhart Gibson, M.D., seconded by Mr. W. B. Alexander, M.A. The other, entitled "The Scientific Breeding of Sheep," was held on 18th October. The Premier of Queensland, the Hon. E. G. Theodore, presided. A vote of thanks was accorded the lecturer on the motion of Mr. A. H. Whittingham, seconded by Professor Goddard, B.A., D.Sc.

ABSTRACT OF PROCEEDINGS, 24TH NOVEMBER, 1923.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 24th November, 1923.

The President, Dr. E. O. Marks, B.A., B.E., M.D., in the chair.

The minutes of the previous Monthly Meeting were read and confirmed.

T. G. H. Jones, B.Sc., A.I.C., and P. C. Tibbits were nominated for membership.

The President announced that as the result of a deputation to the Premier, the Hon. E. G. Theodore, the Government had consented to subsidise the Society to the

extent of £ for £ of the amount expended in printing up to £150 per annum. The deputation consisted of Professors Richards and Goddard and himself.

Mr. H. A. Longman, F.L.S., exhibited a sub-fossil aboriginal mandible, dredged with sand and gravel from the Brisbane River near Indooroopilly Bridge and presented to the Queensland Museum by Dr. E. S. Jackson, which was within the range of variation of present-day specimens. He also exhibited a young *Pteropus poliocephalus* (head and body 155 mm. in length), which was attached to its mother when shot during flight.

Mr. B. Dunstan, Chief Government Geologist, delivered a lecture entitled "Some New Ideas on the Artesian System." His remarks were illustrated by a series of coloured lantern slides. Messrs. Tibbits, Prof. Richards, J. B. Henderson, Prof. Goddard, and the President took part in the discussion on the subject.

A paper by T. G. Jones, B.Sc., and F. B. Smith, B.Sc., entitled "The Composition of the Volatile Oil of the Leaf of *Daphnandra aromatica*," was tabled and taken as read.

Publications have been received from the following Institutions, Societies, etc., and are hereby gratefully acknowledged.

AFRICA.

Durban Museum, Durban.

AMERICA.

BRAZIL—

Instituto Oswaldo Cruz, Rio Janeiro.

CANADA—

Department of Mines, Ottawa.
Royal Canadian Institute, Toronto.
Royal Astronomical Society of Canada, Toronto.
Royal Society of Canada, Ottawa.

UNITED STATES—

American Academy of Arts and Sciences, Boston.
American Geographical Society, New York.
Academy of Natural Science, Philadelphia.
American Philosophical Society, Philadelphia.
Californian Academy of Science, San Francisco.
Indiana Academy of Science.
Rochester Academy of Science.
National Academy of Science and Smithsonian Institute, Washington.
Library of Congress.
American Museum of Natural History, New York City.
New York Zoological Society, New York.
Department of Agriculture.
Arnold Arboretum.
Department of Commerce, New York.
Missouri Botanic Gardens, St. Louis, Missouri.
University of California, Berkley.
University of Colorado.
Cornell University.
John Hopkins University.
University of Illinois, Urbana.
Ohio State University.
University of Kansas, Lawrence.
University of Minnesota, Minneapolis.
Oberlin College.
National Research Council.
Buffalo Society of Natural Science.
Portland Society of Natural History.
Lloyd Library.
The University of Michigan, Michigan.
Bernice Pauahi Bishop Museum, Honolulu, Hawaiian Islands.

MEXICO—

Instituto Geologico de Mexico, Mexico.
Sociedad Cientifica, Mexico.

ASIA.

INDIA—

Colombo Museum, Colombo, Ceylon.
Agricultural Institute, Pusa, Bengal.
Geological Survey of India.
Superintendent, Government Printing.
Survey of India, Dehra Dun.

JAVA—

Department van Landbrouw, Batavia.
Koninckiyke Naturkundige, Batavia.

PHILIPPINE ISLANDS—

Bureau of Science, Manila.

AUSTRALIA AND NEW ZEALAND.

QUEENSLAND—

Field Naturalists' Club, Brisbane.
Geological Survey of Queensland, Brisbane.
Queensland Museum, Brisbane.
Government Statistician, Brisbane.

NEW SOUTH WALES—

Australasian Association for the Advancement of Science, Sydney.
Department of Agriculture, New South Wales.
Botanic Gardens, Sydney.
Geological Survey of New South Wales, Sydney.
Public Library, Sydney.
Linnean Society of New South Wales, Sydney.
Australian Museum, Sydney.
Royal Society of New South Wales, Sydney.
Naturalists' Society of New South Wales, Sydney.
University of Sydney.

VICTORIA—

Bureau of Census and Statistics, Melbourne.
Royal Society of Victoria, Melbourne.
Field Naturalists' Club, Melbourne.
Department of Agriculture, Melbourne.
Department of Mines, Melbourne.
Australasian Institute of Mining and Metallurgy, Melbourne.
National Museum, Melbourne.
Institute of Science and Industry, Melbourne.
Scientific Australian.

TASMANIA—

Royal Society of Tasmania, Hobart.
Field Naturalists' Club, Hobart, Tasmania.
Geological Survey of Tasmania.

SOUTH AUSTRALIA—

Royal Society of South Australia, Adelaide.
Royal Geographical Society of South Australia, Adelaide.
National Museum of South Australia, Adelaide.
Geological Survey of South Australia, Adelaide.

WEST AUSTRALIA—

Royal Society of West Australia, Perth.
Geological Survey of West Australia, Perth.

NEW ZEALAND—

Auckland Institute, Auckland.
New Zealand Board of Science and Art.
Dominion Laboratory, Wellington.
Geological Survey of New Zealand.
New Zealand Institute, Wellington.

EUROPE.

AUSTRIA—

Annals Natural History Museum, Vienna.

BELGIUM—

Académie Royale, Brussels.
Société Royale de Botanique de Belgique.
Société Royale de Zoologique de Belgique.

CZECHO-SLOVAKIA—

Spolecnosti Entomologické, Prague.

GREAT BRITAIN—

Cambridge Philosophical Society.
Conchological Society of Great Britain and Ireland.
Imperial Bureau of Entomology, London.
Literary and Philosophic Society, Manchester.
Royal Society of London.
Royal Botanic Gardens, Kew.
Royal Colonial Institute, London.
Royal Society of Edinburgh.
Botanic Society, Edinburgh.

GERMANY—

Bibliothek der Bayer, Akademie der Wissenschaften, Munich.
Notgemeinschaft der Deutschen Wissenschaft, Berlin.
Senckenbergischen Bibliothek, Frankfurt, A.M.

FRANCE—

Société Geologique et Mineralogique de Bretagne, Rennes.
Société Botanique de France, Paris.
Musee d'Histoire Naturelle, Paris.
Société Scientifique Naturelle, Nantes.
Office Scientifique Pêches Maritimes.
Observations Meteorologique de Mont Blanc.

ITALY—

Societa Agricana d'Italia, Naples.
Instituto di Bologna.
Societa Toscana di Scienze Naturali, Pisa.

POLAND—

Univesitatis Liberæ Polonæ.

SPAIN—

Real Academia de Ciencias de Madrid.
Real Academia de Ciencias de Barcelona.
Academia de Ciencias de Zaragoza.

SWEDEN—

Geological Institute, Upsala.

SWITZERLAND—

Naturforschende Gesellschaft, Basle.
Naturforschende Gesellschaft, Zurich.
Société de Physique et d'Historie Naturelle, Geneva.
International Labor Office, Geneva.

List of Members.

Corresponding Members.

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David, Professor Sir T. W. E., F.R.S.	The University, Sydney, N.S.W.
‡Domin, Dr. K.	Czech University, Prague, Bohemia.
‡Hedley, C., F.L.S.	Assistant Curator, Australian Museum, Sydney, N.S.W.
Liversidge, Prof. A., F.R.S.	Fieldhead, Coombe Warren, Kingston Hill, Surrey, England.
‡Maiden, J. H., I.S.O., F.R.S., F.L.S.	Botanic Gardens, Sydney, N.S.W.
‡Maitland, A. Gibb, F.G.S.	Geological Survey Office, Perth, W.A.
Rennie, Professor E. H.	The University, Adelaide, S.A.
‡Skeats, Professor E. W.	The University, Melbourne, Vic.

Ordinary Members, Etc.

Alexander, W. B., M.A.	Prickly-pear Laboratory, Sherwood.
Appleby, W. E.	Sugar Refinery, New Farm.
Bage, Miss F., M.Sc.	The Women's College, Kangaroo Point, Brisbane.
†Bagster, L. S., D.Sc.	The University, Brisbane.
‡†Bailey, J. F.	Botanic Gardens, Adelaide, S.A.
Ball, L. C., B.E.	Geological Survey Office, Melbourne Street, South Brisbane.
‡†Bancroft, T. L., M.B.	Eidsvold, Queensland.
‡Bancroft, Miss M. J., B.Sc.	Medical School, The University, Sydney.
Barker, Miss E., B.A.	Girls' State School, South Brisbane.
Barton, E. C., A.M.I.C.E.	care of National Bank of Australasia, 4 Queen Victoria Street, London.
Berney, F. L.	Barcarolle, *via* Longreach.
‡Bennett, F., B.Sc.	State School, Toowong, Brisbane.

† Life Members.
‡ Members who have contributed papers to the Society.

Bick, E. W.	Botanic Gardens, Brisbane.
Bradley, H. Burton, M.B., Ch.M. ..	Longueville, North Shore, Sydney.
‡Brunnich, J. C., F.I.C.	Agricultural Chemist's Lab., William Street, Brisbane.
‡Bryan, W. H., M.Sc.	The University, Brisbane.
Brydon, Mrs.	Department Public Instruction, Brisbane.
Bundock, C. W., B.A.	"Kooralbyn," Beaudesert.
Butler-Wood, F., D.D.S.	Permanent Chambers, Adelaide Street, Brisbane.
Butler-Wood, Miss I. V., B.D.S. ..	Dornoch Terrace, West End.
Cameron, W. E., B.A.	Tanbun Road, Ipoh, Perak, Federated Malay States.
Cayser, A. A., B.Sc.	The University, Brisbane.
Cilento, R. W., M.D., B.S.	Institute of Tropical Medicine, Townsville.
‡Colledge, W. R.	Friendly Societies' Dispensary, George Street, Brisbane.
Colvin, Joseph	George Street, Brisbane.
‡Cooling, L. E.	Institute of Tropical Medicine, Townsville.
Cumbrae-Stewart, F. W. S., D.C.L.	The University, Brisbane.
Dixon, G. P., C.B.E., M.B., Ch.M. ..	Wickham Terrace, Brisbane.
‡Dodd, Alan P.	Prickly-Pear Laboratory, Sherwood, Brisbane.
Drewitt, G. E.	Narrandera, N.S.W.
Duhig, J. V., M.B.	Edmonton, Wickham Ter., Brisbane.
Duhig, Archbishop, D.D.	"Dara," Brisbane.
Dunstan, B.	Geological Survey Office, Melbourne Street, South Brisbane.
‡Francis, W. D.	Botanic Gardens, Brisbane.
Froggatt, J. L., B.Sc.	Department of Agriculture, Brisbane.
†Gailey, R.	Courier Buildings, Queen Street, Brisbane.
Gibson, J. Lockhart, M.D.	Wickham Terrace, Brisbane.
‡Gillies, C. D., M.Sc.	Club House, The University, Melbourne.
Goddard, Prof. E. J., B.A., D.Sc. ..	The University, Brisbane.
Graff, R., B.Sc.	Medical School, The University, Melbourne.

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‡ Members who have contributed papers to the Society.

‡Grey, Mrs. B. B., F.L.S.	care of Queensland Trustees Ltd., Margaret Street, Toowoomba.
Greene, Miss A.	High School, Wynnum.
‡Gurney, E. H.	Agricultural Chemists' Lab., William Street, Brisbane.
Guthrie, F. B., F.I.C.	care of Daily Mail, Brisbane.
Hamlin, J. C., M.Sc.	care of Prickly-pear Laboratory, Sherwood.
Hamlin, Mrs. J. C., M.A.	care of Prickly-pear Laboratory, Sherwood.
‡Hamlyn-Harris, R., D.Sc.	Hookworm Campaign, Brisbane.
Hardcastle, Mrs. T., B.Sc.	Jinbiggaree, near Dugandan.
Hardy, G. H.	Biology Department, The University, Brisbane.
‡Hawken, Professor R. W., B.A.	The University, Brisbane.
‡Henderson, J. B., F.I.C.	Government Analyst, Brisbane.
Heney, T. W.	The Telegraph, Brisbane.
Hitchcock, L. F.	Prickly-Pear Laboratory, Sherwood.
Holdaway, F. G., B.Sc.	Department of Agriculture and Stock, Brisbane (Associate).
Hulsen, R.	238 Edward Street, Brisbane.
Illidge, T.	Markwell Street, Toowong.
Jackson, A. G.	Synchronome Co., Ann Street, Brisbane.
‡Jensen, H. I., D.Sc.	Treasury Chambers, George Street, Brisbane.
‡Johnston, Professor T. Harvey, M.A., D.Sc.	The University, Adelaide.
Just, J. S.	care City Electric Light Company, Boundary Street, Brisbane.
‡Lambert, C. A.	care Bank of N.S.W., Melbourne, Vic.
Lloyd, W.	Queensland Correspondence College, Adelaide Street, Brisbane.
‡Longman, H. A., F.L.S.	Queensland Museum, Brisbane.
‡Love, W., M.B., Ch.M.	1 Wickham Terrace, Brisbane.
Lowson, Professor J. P., M.A., M.D.	Lauriston, Wickham Terrace, Brisbane.
Ludgate, Miss B., B.A.	Teachers' Training College, Brisbane.
Lumley Hill, Mrs. E.	Belle Vue, *via* Coominya, Esk Line.

† Life Members.

‡ Members who have contributed papers to the Society.

Marks, Hon. Dr.	101 Wickham Terrace, Brisbane.
Marks, A. H., C.B.E., D.S.O., M.D.	Wickham Terrace, Brisbane.
Marks, E. O., M.D., B.A., B.E. ..	101 Wickham Terrace, Brisbane.
‡McCall, T., F.I.C.	Government Analyst's Department, Brisbane.
McDonald, S. F., M.D., M.R.C.P. ..	Fancourt, Wickham Terrace, Brisbane.
McMinn, J.	State School, Kelvin Grove, Brisbane.
Massey, Rev. C. H.	Murgon.
Mathewson, J. H. R., M.B., Ch.B. ..	New Farm, Brisbane.
Merrington, Rev. E. N., Ph.D. ..	Dunedin, N.Z.
Morris, L. C., A.M.I.C.E.	Department of Public Instruction, George Street, Brisbane.
Morton, C., A.T.C.S.M.	Geological Survey Office, Melbourne Street, South Brisbane.
Moxon, Miss C.	Broughton Estate, Toowong (Associate).
Muir, Miss E.	Taringa (Associate).
Parker, W. R., L.D.S.	185 Edward Street, Brisbane.
Parnell, Professor T., M.A. ..	The University, Brisbane.
‡Pearce, Mrs. T. R., M.Sc.	"Nattai," Beresford Avenue, Chatswood, Sydney.
‡Pound, C. J., F.R.M.S.	Bacteriological Institute, Yeerongpilly.
‡Priestley, Professor H. J., M.A. ..	The University, Brisbane.
‡Reid, J. H.	Geological Survey Office, Melbourne Street, South Brisbane.
‡Richards, Professor H. C., D.Sc. ..	The University, Brisbane.
†Riddell, R. M.	Department Public Instruction, Brisbane.
†Roe, R. H., M.A.	Figtree Pocket.
Saint-Smith, E. C., A.S.T.C. ..	Geological Survey Office, Melbourne Street, South Brisbane.
Sankey, Major J. R.	Flavelle's, Queen Street, Brisbane.
Saunders, G. J., M.Sc., B.E. ..	Central Technical College, Ipswich.
Shepherd, S. R. L.	Geological Survey Office, Brisbane.
Simmonds, J. H., B.Sc.	Department of Agriculture and Stock, Brisbane (Associate).
Skertchly, Professor S. B. J. ..	Molendinar, S.C. Line.
‡Smith, F., B.Sc., F.I.C.	Hutton's Factory, Zillmere.
†Steel, T.	Stephens Street, Pennant Hills, Sydney, N.S.W.

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‡ Members who have contributed papers to the Society.

Swanwick, K. ff., B.A., LL.B. ..	The University, Brisbane.
Swain, E. H. F.	Director of Forests, Brisbane.
Sylow, Paul	Sugar Refinery, New Farm.
‡Taylor, Hon. W. F.	Preston House, Queen Street, Brisbane.
Thompson, C. L., B.D.Sc.	89-91 Queen Street, Brisbane.
Thynne, Hon. A. J.	195 Edward Street, Brisbane.
‡Tiegs, O. W., D.Sc.	The University, Adelaide, S.A.
‡Tryon, H.	Department of Agriculture, Brisbane.
‡Turner, A. J., M.D., F.E.S. ..	131 Wickham Terrace, Brisbane.
Walker, A. R., D.D.S., L.D.S. ..	Edward Street, City.
Walker, Miss Mavis J., M.Sc. ..	The University, Brisbane.
†Walkom, A. B., D.Sc.	Linnean Society House, Elizabeth Bay, Sydney.
Watkins, S. B., M.Sc.	Central Technical College, Brisbane.
Wearne, R. A., B.A.	Central Technical College, Brisbane.
†Weedon, W.	"Innisfail," Wickham Terrace, Brisbane.
‡White, C. T., F.L.S.	Government Botanist, Botanic Gardens, Brisbane.
‡Whitehouse, F. W., B.Sc.	King's College, Brisbane (Associate).

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